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Expanded Clay Aggregate.

A NUMBER of experimental houses has been built at Northolt by the Ministry of Works in order to ascertain the relative costs of houses built with different materials and with different fittings. The materials used for the construction of the walls include brick, clinker concrete, and concrete made with foamed slag and expanded clay aggregate. The last-named material was supplied by the Tunnel Portland Cement Co., Ltd., who have supplied the following notes on the material.

Apparent specific gravity, 0·48 to 0·68 (mean of 7 determinations, 0·59).

Density.—$\frac{3}{4}$ to $\frac{3}{16}$ in., 34·2 lb. per cubic foot; $\frac{3}{16}$ in. to dust, 46·4 lb. per cubic foot.

Proportions.—The quantities used per cubic yard of concrete were: Coarse aggregate, 662 lb.; fine aggregate, 815 lb.; cement, 561 lb.; water, 478 lb.; total, 2,516 lb. A water-cement ratio of 0·852 was found to give an easily workable concrete.

Weight of concrete.—Fresh, 91·5 lb. per cubic foot; dry, 79·4 lb. per cubic foot.

Compressive strength of 6-in. cubes.—1 day, 458 lb. per square inch; 3 days, 1,300 lb. per square inch; 7 days, 2,136 lb. per square inch; 28 days, 3,013 lb. per square inch.

Percolation.—A percolation test was carried out on concrete composed of 1 part of cement to 2 parts of aggregate by volume. Slabs measuring 9 in. by 9 in. by $1\frac{3}{4}$ in. were cast on edge and cured for 14 days. A water pressure of 30 lb. per square inch was applied to one face over a surface of 5 in. diameter and maintained for four days. The slabs were then broken and the depth of penetration determined. The results were as follows:—

	Floating Aggregate	Sinking Aggregate	Equal Volumes of Floating and Sinking Aggregate
Total water passing at end of 4 days	Nil	Nil	Nil
Depth of penetration (in.) ..	1·3	0·3	0·6

Lightweight Concrete Aggregates.

A new edition has just been published of Building Research Bulletin No. 15, entitled "Lightweight Concrete Aggregates," by Dr. F. M. Lea, D.Sc., F.I.C. (London: H.M. Stationery Office. Price 3d.) The bulletin gives much useful information on the properties of lightweight concrete aggregates that are being increasingly used, and which will no doubt play a considerable part in the erection of houses and other structures after the war. Tables are given comparing the properties of concretes made with coke breeze, pumice, foamed slag, and expanded slate.

The compressive strength of concrete made with pumice in mixes not richer than 1 : 6 is given as 200 to 550 lb. per square inch, and the strength of coke breeze and clinker concrete in mixes not richer than 1 : 6 is given as 150 to 450 lb. per square inch. The compressive strength of foamed slag concrete is given as follows: 1 : 6 mix by volume, 800 to 2,000 lb. per square inch; 1 : 10 mix by volume, 600 to 750 lb. per square inch. In the case of expanded slate the strength of a 1 : 6 mix is given as 600 to 1,100 lb. per square inch, and a 1 : 11 mix as 250 to 350 lb. per square inch.

The densities of these concretes in an air dry condition are: Pumice 45 to 70 lb. per cubic foot; coke breeze and clinker, 50 to 95 lb. per cubic foot; foamed slag, 80 to 95 lb. per cubic foot for a 1 : 6 mix and 65 to 95 lb. per cubic foot for a 1 : 10 mix; expanded slate, 40 to 80 lb. per cubic foot for a 1 : 6 mix and 35 to 60 lb. per cubic foot for a 1 : 11 mix.

Other properties of foamed slag concrete are given, from which the following details are abstracted.

1 : 1 : 2 mix, water-cement ratio 0·45: Compressive strength at 28 days, 4,495 lb. per square inch; density, 115 lb. per cubic foot; drying shrinkage, 0·056 per cent.; moisture expansion, 0·054 per cent.

1 : 2 : 4 mix, water-cement ratio 0·74: Compressive strength, 1,540 lb. per square inch; density, 90 lb. per cubic foot; drying shrinkage, 0·049 per cent.; moisture expansion, 0·043 per cent.

1 : 4 : 8 mix, water-cement ratio 1·39: Compressive strength, 469 lb. per square inch; density, 78 lb. per cubic foot; drying shrinkage, 0·044 per cent.; moisture expansion, 0·037 per cent.

The following details relate to mixes in which the fine aggregate is river sand and the coarse aggregate is foamed slag. 1 : 1 : 2 mix, water-cement ratio 0·45: Compressive strength at 28 days, 6,400 lb. per square inch; density, 126·5 lb. per cubic foot. 1 : 2 : 4 mix, water-cement ratio 0·74: Compressive strength, 3,080 lb. per square inch; density, 115·0 lb. per cubic foot. 1 : 4 : 8 mix, water-cement ratio 1·39: Compressive strength, 770 lb. per square inch; density, 106·5 lb. per cubic foot.

It is pointed out that porous lightweight concretes cannot be expected to afford a high degree of protection to embedded steel, and if exposed to external corrosive agencies some additional protection will be necessary. Heavier light-

weight aggregates containing sand as a fine aggregate can be made adequately impermeable provided that a sufficiently rich mix is used. Natural pumice, expanded clays, shales, slates and slags should not exert any definitely corrosive effects.

The thermal conductivities of lightweight concretes, in B.Th.U.'s per square foot per hour per 1-in. thickness per 1 deg. difference in temperature between surfaces are stated to be as follows: Pumice concrete, 1 : 6 mix, 1·4 ; 1 : 10 mix, 1·1. Clinker concrete, 1 : 6 mix, 2·8 ; 1 : 10 mix, 2·3. Foamed slag concrete, 1 : 6 mix, 2·2 ; 1 : 10 mix, 1·7. Expanded slate concrete, 1 : 6 mix, 2·1 ; 1 : 10 mix, 1·7. Comparable figures of gravel concretes are as follows : 1 : 1 : 2 mix, 6·7 ; 1 : 2 : 4 mix, 7·0.

The Ministry of Works has used foamed slag and expanded clay aggregates in the construction of some experimental houses at Northolt. The proportions and gradings used are as follows :

The foamed slag concrete was mixed in the proportions of 112 lb. (1¼ cu. ft.) of Portland cement, 1 part sand, and 13 parts of foamed slag. The foamed slag comprised 9 parts of material from ½ in. to ⅛ in. and 4 parts from ⅛ in. to dust. In the precast units the proportions were 1 part Portland cement, 2 parts fine material, and 4 parts from ¾ in. to $\frac{3}{16}$ in.

In the case of the expanded clay aggregate the proportions were 112 lb. of Portland cement to 7½ cu. ft. of aggregate ; 45 per cent. of the aggregate passed a ¾-in. mesh and was retained on a $\frac{3}{16}$-in. mesh, and 55 per cent. was from $\frac{3}{16}$ in. down. Further information on the properties of expanded clay aggregate have already been given.

What is known as " no-fines " concrete was also used for a pair of these experimental houses. In this type of concrete a large proportion of voids is relied upon for lightness in weight and for insulation. The aggregate comprised clinker between ¾ in. and ⅜ in., with not more than 5 per cent. passing a ⅜-in. sieve. The proportions were 1 part of Portland cement to 6 parts clinker. Enough mixing water is used to provide a mortar that will coat and adhere to the particles of aggregate without filling the voids. The result is a mixture that contains no grout that will flow, and in order to preserve the voids the concrete is consolidated in the shutters by light rodding only. The porous aggregates are soaked in water before mixing so that they will not absorb the mixing water necessary for the setting and hardening of the cement.

Electric Haulage in Cement Works Quarry.

SINCE 1940 the original quarry face at the Railton, Tasmania, works of the Goliath Portland Cement Company, which was worked with its floor at approximately the same level as the crushing plant, has been nearly worked out, and the second face has been worked back until almost on the centre line of the crushing station, but some 40ft. below crusher level. With the virtual completion of operations on the original floor level, the overburden problem in future is limited to intrusions which diminish at lower depths, and plans have been completed for opening up a third working floor in almost solid limestone at a depth of 90ft. below the crushing station.

The elevating of quarried stone to plant level was considered by three different methods : (1) By continuing the present system of roadways up which the loaded lorries would travel to the crushing station. (2) By installing the 42-in. by 36-in. primary crusher below the floor level of the third cut and transporting the first crushing by belt conveyor to the hammer mill at its present site. (3) By an electric haulage system which would pull loaded motor trucks up to crusher level. It was decided to use the haulage system as providing the cheapest and most efficient method of operation, which necessitated no plant alterations, and retained the full mobility of the quarry equipment.

As there is still a considerable quantity of stone to be worked from the second floor level, the haulage system was installed to handle this stone now, thus reducing lorry operating costs, and to extend the system when the third floor is opened up at the — 90 ft. level. The following notes on the system are abstracted from the " Commonwealth Engineer " for July, 1944.

War-time difficulty in obtaining ideal equipment had to be faced, and the winch motor installed was an available slow-speed slip-ring motor of 50 h.p. running at 425 r.p.m., whereas the winch is designed to take a 100-h.p. motor of the same speed at a later date, which will be able to haul gross loads of 30 tons up the 1 : 6 grade. This incline was established as the reasonable limit at which stone was unlikely to roll off the open-ended lorry bodies, and has proved entirely satisfactory in practice.

The haulage-way is paved with concrete (Fig. 1). The sequence of operations is as follows :—The " Barney car," weighing 1 ton, pulls the rope to the bottom of the incline as the winch runs " out " and comes to a stop in the pit. The motor lorries have push plates fitted at the rear of and underneath their chassis, against which the curved and rubber-cushioned buffer plate on the " Barney car " engages. A loaded motor lorry, on approaching the incline, straddles the pit into which the Barney car has receded and is located fairly centrally by the guiding kerbs on each side. Speed is reduced to about 2 m.p.h. and, after passing over the pit, the front wheel of the lorry starts the winch through contactor gear by depressing a switch-actuating member. The car comes up behind the lorry and engages with it, when the lorry driver goes into neutral gear. A very little practice enables drivers to regulate their speed so that engagement

is free from jar, but the length of rope provides an effective spring in the case of any misjudgment, and the car can actually start a lorry from stationary without mishap.

On approaching the top of the incline the flange of the leading wheel on the Barney car rides over a switch actuator which stops the winch, and at this moment the driver engages gear and the lorry engine takes over the load. The Barney car is then in the top position. In the event of accidental stalling of the

Fig. 1.—Electric Haulage in a Cement Works Quarry.

engine, the lorry is held stationary by the Barney car still in position behind, and cannot run backwards. As the lorry travels on under its own power a front wheel rolls over another switch actuator which starts the winch in the " down " direction, until the Barney car operates a " stop " switch as it enters the pit, leaving it in correct position for the next lorry.

The motor lorries operate the starting of the winch in each direction, while the Barney car operates the " stop " switches at each end of the incline. In addition to these stop switches, two limit switches are operated by a screw driven from the shaft of the winch drum. These limit switches are set to act just a

moment later than the switches operated by the Barney car. Additional safeguards are provided in the form of a wire, which the lorry driver can reach from his cab, to stop the winch anywhere on the incline, while an automatic stop switch comes into action should a stone roll off the lorry and foul the Barney car on the down run.

Haulage speed is 260 ft. per minute. The maximum gross load which the winch will pull is about 23 tons, but when hauling the larger type of trucks which have a loaded weight around this figure, slight engine assistance is given which leaves the winch to deal with an effective load of 16 to 18 tons.

The larger motor for which the plant is designed will deal very easily with 30-ton loads which are contemplated at a later date. A solenoid brake acting on the first motion shaft of the winch comes on immediately any "stop" switch is operated. The use of this haulage eliminates all heavy up-grade work and means much easier operating conditions for lorry engines and transmissions, besides effecting a considerable saving in fuel, oil and tyres. The empty lorries return to the quarry down a metalled roadway alongside the haulage way. It was advisable not to concrete this down grade as under certain conditions with wet clay on a 1 : 6 concrete surface there would be a risk of lorries getting out of control.

Influence of Capping on Cube Tests.

A SERIES of tests has been carried out by Mr. P. Nycander at the Swedish State Testing Laboratory, Stockholm, on the influence of the capping on the results of compression tests of concrete cubes. The factors studied included the type of cement used for the capping mortar, the thickness of the capping, the strength of the mortar capping at different ages, and the planeness of the surface of cubes tested without capping. Calcium sulphate plaster gave such a low strength as to be unsuitable for capping. There was apparently no advantage in concentrating the load by using a reduced compression area. The author expresses the opinion that, in view of the effect of the capping on the results of compression tests, the nature of the capping should be clearly defined. It is suggested that cubes cast in a wood mould should have a capping about 3 mm. thick of a plastic cement mortar containing equal parts of cement and sand with a maximum particle size of 1 mm. If rapid-hardening cement is used the test should be made at 24 hours, or at 4 days if Swedish "A" cement is used.

Laboratory Apparatus.

A NUMBER of leaflets has been issued by Messrs. Griffin & Tatlock, Ltd., of Kemble Street, London, W.C.2, describing some recent additions to their list of laboratory apparatus. These include a new type of calcium chloride desiccator for use in instrument cases, an alumina for polishing metal surfaces for microscopic examination, a glass-cutting knife, an anti-vibration balance table, a nitrogen-in-steel determination apparatus, a vibratory ball mill for grinding to a fine powder, and an apparatus for the determination of benzole toluene and phenols.

Heat Economiser for Wet and Dry Process.

By HENRY POOLEY, B.Sc., M.Inst.C.E., M.I.Mech.E.

IN the manufacture of cement by both the wet and dry processes there are several well-known methods of economising heat in clinker burning. This article deals with two new systems integral with the kiln—one for the wet and one for the dry process—but before these are described other methods will be briefly noted.

So far as the wet process is concerned various systems have been tried, such as the slurry atomiser which was not developed beyond the experimental stage, a very long kiln with chains (still extensively used), and so on, as well as various apparatus not integral with the kiln such as the slurry dryer and the calcinator. The results obtained by these machines depend upon the chemical nature and the physical properties of the raw materials as well as upon the apparatus.

With the Miag calcinator, assuming standard coal and 40 per cent. slurry moisture, it should be possible to attain a coal consumption in the neighbourhood of 23 per cent. This is generally accompanied by dust—in some cases as much as 25 per cent. of the raw material introduced into the system has been recorded as dust. This requires the installation of dust-collecting plant, which might need to comprise both mechanical filters and electrical precipitation.

In the case of the Polysius slurry dryer, the fuel consumption is in general a little higher, but the dust generation is usually less. In this case, especially with some raw materials, it might be sufficient to install only a mechanical separator, especially if the kiln is not forced, but the capital cost is high owing to the necessity for a tall structure at the back end of the kiln. Under good conditions, with 40 per cent. slurry moisture, a coal consumption of 24 per cent. (standard) might be expected.

The long kiln furnished with chain curtains is now well established, but takes up more space than the non-integral arrangements and creates dust with many raw materials. Here the coal consumption may be a shade higher than that obtained with the Polysius slurry dryer.

So far as the dry process is concerned, possibly the most economical unit is the Polysius Lepol kiln. The details of this are well known, and under favourable conditions it is possible to obtain a coal consumption as low as 13 per cent. of standard coal. This apparatus is expensive and may cause dust. In theory the amount of dust generated should be reasonably low, but works visited by the writer which have Lepol kilns installed have not been dustless. For example, at a works at Reuchenette in Switzerland, situated in a charming valley, electrical dust precipitation plant had to be installed in order to satisfy the local authorities, and this is only one case. Miag calcinators are used in the dry process. This machine was installed in the Terni works near Rome, but the apparatus generated much dust and would require very elaborate dust-collecting plant. The fuel consumption, however, was in the neighbourhood of 15 per cent. to 16 per cent. of standard coal.

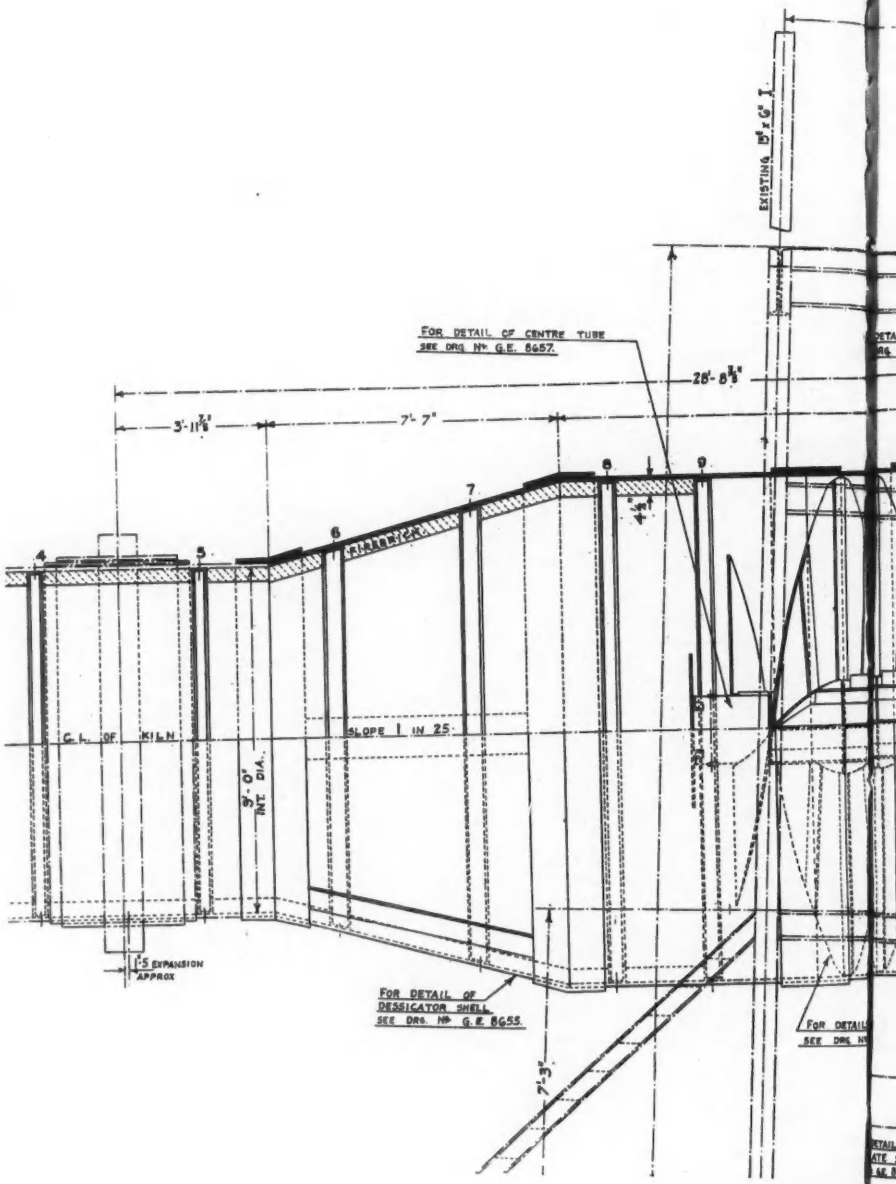
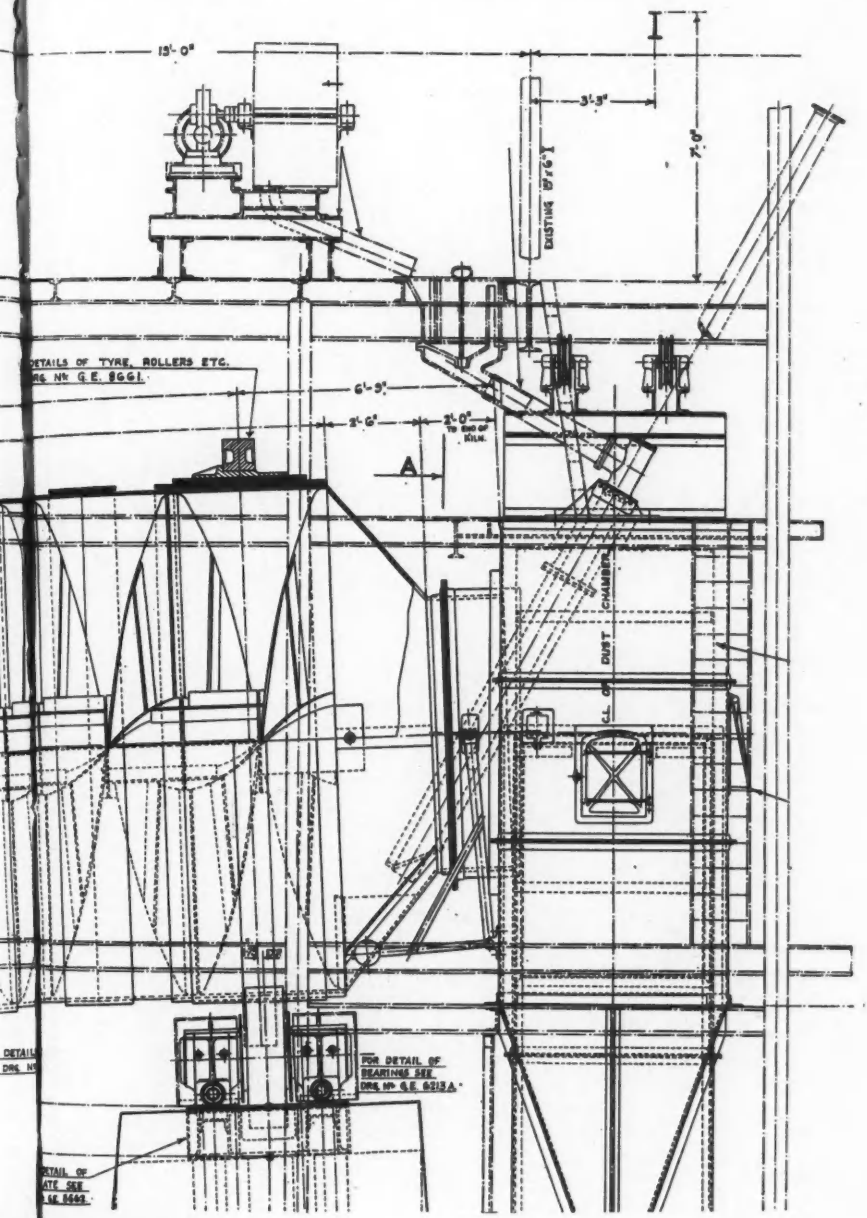


Fig. 1.—Arrange-Pr



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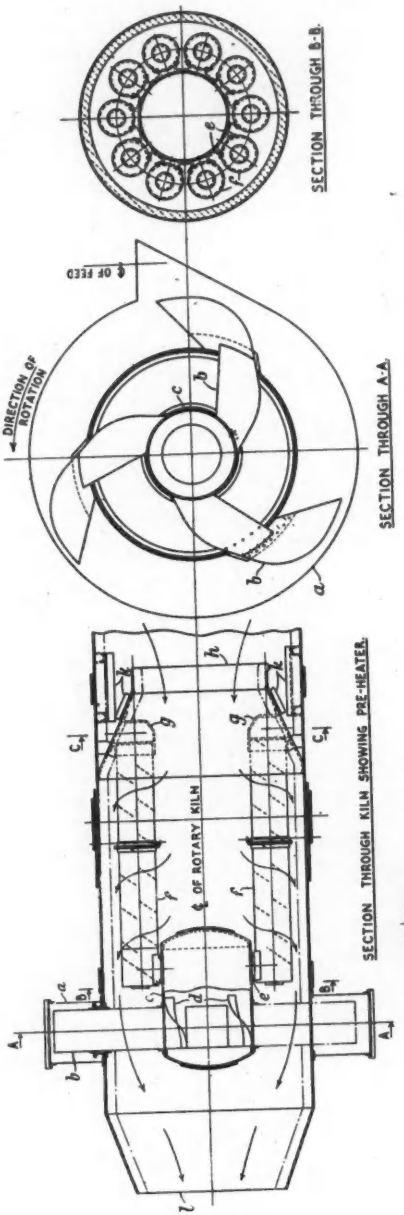

ARRANGEMENT OF PRE-HEATER FOR DRY PROCESS ROTARY KILN

Fig. 2.

So far the machines referred to, with one or two minor exceptions, have been of foreign origin. We now come to exclusively British designs for heat economy, one of which applies to the wet process and the other to the dry process.

Wet Process.

Vickers-Armstrongs have designed an extension of the kiln which is integral with it, which they term a "desiccator." The apparatus has been installed in various places in recent years, and the latest installation is at the Aberthaw works of the Aberthaw and Bristol Channel Portland Cement Co., Ltd. This installation is of interest in that the writer has never come across a piece of apparatus which gave such good performance from the start with less trouble.

In an ordinary wet-process rotary cement kiln the temperature of the exhaust gases, usually in the region of 400 deg. C. to 450 deg. C., is too low to enable gases to be economically used for other purposes, such, for example, as waste-heat boilers, with the result that the heat in these gases is dissipated into the atmosphere; it is with the object of reducing this waste of heat that manufacturers of cement-making machinery have for a number of years concentrated on this problem, and the various types of slurry dryers noted have been evolved.

Fig. 1 shows a typical desiccator, which comprises an enlarged feed zone constructed of boiler-quality mild steel plates and provided with a number of quick-release access doors for examination and erection purposes. A mild steel two-start spiral, built up in segments, is constructed for whirling the exhaust gases. The spiral is constructed in sections for ease of handling, each section comprising four segments of spiral welded to a central steel sleeve, the whole of the sections being then mounted on a central steel tube thus forming a continuous double spiral. Clamping rings are provided at each end of the tube for retaining the spiral segments in position. Each spiral segment is secured to its neighbour by a mild steel butt strap, and the periphery of the spiral is connected to the shell of the enlarged zone by mild steel cleats. The whole construction of the spiral is arranged in such a manner as to accommodate any expansion which takes place due to the heat of the exhaust gases. The main feature of the desiccator is the special arrangement of the heat-exchange chains. This arrangement was evolved after exhaustive practical trials, and the chains are hung in such a manner as not only to prevent them becoming tangled (there being no loose ends), but also to be self-cleaning.

From tests it has been found that with the desiccator the back-end temperature of the kiln exhaust gases has been reduced from approximately 400 deg. C. to 150 deg. C. to 180 deg. C., which is equivalent to a saving in fuel of 450 to 500 kilogramme-calories per kilogramme of clinker; in other words, the consumption of standard coal has been reduced by approximately 20 per cent. when using normal slurries. A further feature of the desiccator is that the spiral collects some dust in a similar manner to a cyclone, the dust being deposited on the wet blades of the spiral as well as on the chains. Another feature of the desiccator is its simplicity. The power consumption is comparatively low, and the labour for operation is light. Furthermore, upkeep and maintenance are low.

Some actual results can now be quoted. At the Chinnor works in Oxfordshire the desiccator was installed just before the war, and much experimental work was done by Mr. A. A. Short, director and manager. The overall length of the installation is 203 ft. including the cooler and desiccator. The desiccator is 12 ft. 6 in. internal diameter, whilst the kiln portion is 9 ft. in diameter (parallel) and has 9,162 cu. ft. capacity. The guaranteed output of the kiln was 7.15 tons per hour and an output of 8.5 to 8.75 tons per hour is obtained. The guaranteed coal consumption was 1,630 kilo calories per kilo of clinker, which represents about 23.9 per cent. standard coal, but in practice this appeared to be less, i.e. about 23.5 per cent. as the exit temperature was reduced from 180 deg. C. to 150 deg. C. The guaranteed moisture content of the slurry was 39 per cent., and this is maintained at about 38.5 to 39 per cent.

The average $CaCO_3$ content of the raw mix is 77.6 per cent. for clinker for ordinary Portland cement and 78.3 per cent. for clinker for rapid-hardening Portland cement, while the lime content of the clinker for ordinary cement is 65.6 per cent. and for rapid-hardening cement 67 per cent. to 68 per cent. The exit-gas temperature on test was 180 deg. C., but later averaged 140 deg. C. to 150 deg. C.

The only form of dust collection is a 2-cwt. sack attached to the outlet of the feed hood. This sack is emptied once a day and the dust is either tipped into the washmill or fed to No. 1 kiln through the dust plant. The analysis of the dust was as follows:

Free H_2O	2.45 per cent.
Total SiO_2	16.94 ,, ,,
R_2O_3	7.65 ,, ,,
$CaCO_3$	64.18 ,, ,,
Free CaO	4.49 ,, ,,
MgO, alkalis, etc.	4.29 ,, ,,

Beyond the kiln burner no other operator is required, as the desiccator is fed by means of a spoon feeder synchronised with the kiln speed. The slurry is delivered through a 6-in. pipe which only requires poking occasionally. The feed is regular and perfectly satisfactory, and the burner has no difficulty in burning in this kiln.

Prior to the installation of the full complement of chains, clinker rings used to form occasionally, but generally they would break away and pass out of the kiln. Since then, however, no clinker rings have formed. At first it was found that the heat banked up much more at the front end of the kiln than was desirable, and it was decided to use high-alumina instead of silica blocks.

Difficulties were experienced and overcome. In the first place the desiccator was fitted with grates and heat-exchange bodies, but after several test runs it was decided to remove them and fit chains. Immediately there was a great improvement, and it was found that a bigger output could be obtained by further increasing the quantity of chains directly in front of the desiccator in the tapered neck. There is an entire freedom from clinker rings, and the kiln is now extremely simple to operate.

The desiccator recently installed at Aberthaw was attached to an old kiln 200 ft. long by 9 ft. diameter and 10 ft. diameter in the burning zone. The desiccator is 31 ft. 5½ in. long and 13 ft. internal diameter. The kiln was originally designed for an output of 6 tons per hour, but has been increased to 9 tons per hour by merely increasing the quantity of slurry introduced. The desiccator was fitted with chains, and the output of the kiln now averages 10 tons per hour. The coal consumption is approximately 26 per cent. (standard), the slurry moisture being about 36 per cent., and the calcium carbonate content averages 78.36 per cent. The kiln is fitted with an Edgar Allen Vanderwerp recuperator, and the coal is dried and ground separately. The overall length of the Vanderwerp recuperator, the kiln, and the desiccator is 216 ft. 6½ in. Separate drying and grinding of the coal was also practised at Chinnor, but there is no reason why a unit pulverising system utilising heat from the kiln for drying purposes should not be installed.

Dry Process.

Fig. 2 shows a new integral preheater attached to a dry-process kiln. Messrs. Vickers-Armstrongs, Ltd., are also responsible for the design of this apparatus.

In normal practice the dry raw meal fed to the kiln is damped with from 8 per cent. to 10 per cent. of water before entering the kiln, in order to reduce the dust loss. The object of the preheater is to enable the meal to be fed to the kiln in a dry state with the minimum of dust loss and to preheat this material more rapidly and efficiently. This patent preheater comprises an enlarged feed zone built up in boiler-quality mild steel plates and arranged as an extension to the kiln shell. The material to be treated is fed into a mild steel casting (*a*), and as the kiln rotates it is scooped up by cast-iron buckets (*b*) into a central mild steel chamber (*c*) having spirals (*d*) arranged to convey it onwards and past the scoop openings. From the central chamber (*c*) the material falls through the radial chutes (*e*) into a number of thin mild steel tubes (*f*), these tubes being arranged in a circle and longitudinal with the shell of the feed zone. The material is conveyed inside the tubes (*f*) to the discharge chutes (*g*), which are mounted on a mild steel brick-lined cone (*h*) attached to the shell of the enlarged feed zone and forming a reduced outlet for the kiln exhaust gases. The material is delivered quietly between the cone (*h*) and the main shell and out of the way of the path of the gases. Spiral lifters (*k*) are provided at this point to feed the material away from the discharge chutes (*g*). The hot gases being drawn up the kiln, contra-flow to the direction of travel of the material, are drawn through the nose of the cone (*h*) and over the point of feed of the material into the kiln proper. The gases then pass along and around the tubes and finally pass radially between the tubes before being discharged through the outlet (*l*) to the kiln flues and induced-draught fan.

With normal raw materials there should be no difficulty in obtaining a standard coal consumption of approximately 15 per cent., and the dust emission should be sufficiently low to avoid the necessity of elaborate precautions near a built-up area.

The Effect of Alkalis, Soda and Potash on the Hydration of Portland Cement.

AN investigation into the rôle of the alkalis, soda, and potash in hydrating cements has been undertaken by Mr. G. L. Kalousek, of the United States National Bureau of Standards, and is published as Research Paper No. 1590 of the Bureau. The investigation was concerned with the effects of Na_2O on the compositions of the lime silicate hydrates and of the aqueous phase in which they are stable. The investigation was essentially a study of portions of the quaternary system soda-lime-silica-water at 25 deg. C.

In a consideration of the applications of the results of the study to concrete, the author states that the investigation has shown that gels coexisting with crystalline $Ca(OH)_2$ and with solutions containing between 0·0 and 100 gr. of Na_2O per litre have compositions that range between about $2CaO.1SiO_2.xH_2O$ and $0{\cdot}25Na_2O.1CaO.1SiO_2.xH_2O$. If similar relations prevail in a completely hydrated cement, the approximate compositions of the gel and solution may be deduced as follows.

For purposes of illustration, a cement containing 20 per cent. of SiO_2 and 1 per cent. of Na_2O is used. The extent of combination of Na_2O and SiO_2 as a soda-lime-silicate gel will depend on the extent to which the Na_2O-bearing compounds and the two lime silicates have hydrolysed. Because of this the simplest deductions, as follows, are those for a completely hydrated cement. If all of the Na_2O combined with SiO_2 as soda-lime-silicate gel, the $Na_2O : SiO_2$ molar ratio of the gel would be 0·05. A gel of this $Na_2O : SiO_2$ ratio is stable in contact with a solution containing 3 gr. of Na_2O per litre. Since this amount of Na_2O in solution is only 2 per cent. of the total, it may be disregarded in calculating the composition of the gel. A soda-lime-silicate gel coexisting with a solution containing 3 gr. of Na_2O per litre has a $CaO : SiO_2$ molar ratio of 1·4. A combination of the two ratios gives the following composition for the gel: $0{\cdot}05Na_2O : 1{\cdot}4CaO : 1SiO_2 : xH_2O$. The solution in contact with this gel would contain about 3 gr. of Na_2O, 0·1 gr. of CaO, and 0·005 gr. of SiO_2 per litre.

It is recognised that the calculations are not entirely valid. For example, it is probable that a portion of the silica in a completely hydrated cement is present in combinations other than soda-lime-silicate gel. Also the composition of the gel may be altered by the prolonged ageing required to bring about complete hydration of the cement.

In a partially-hydrated cement, the compositions of the gel and solution will differ from those given. It is known that the dicalcium silicate in a cement paste is only slightly hydrated at 28 days, but the tricalcium silicate in the same time may approach a state of complete conversion to its hydration products. Since, on the average, about one-third of the SiO_2 in a cement is combined as dicalcium silicate, it would follow that the gels formed during the earlier periods would contain more Na_2O than those prevailing at complete hydration, providing the

Na_2O-bearing compounds react with water at rates comparable with that of tricalcium silicate. Also the solution would be richer in soda. Making allowance for the average value of SiO_2 combined as dicalcium silicate, calculations indicate that the gels formed during the earlier periods may have $Na_2O : SiO_2$ molar ratios as high as 0·1, and the contact solution may contain as much as 10 gr. of Na_2O per litre.

The different values reported in the literature for the compositions of the silicate gels in hydrated cements may be related to the alkali contents of the cements as indicated by the following considerations. Bogue and Lerch, in a study of the alkali-free lime silicates, came to the conclusion, from results of free-lime determinations, that the hydrated products had compositions approaching a value of $2CaO : SiO_2 : xH_2O$. This result is in accord with that obtained in studies of the system lime-silica-water reported by Flint and Wells and Bessey. Using cements that contained between 0·6 and 1·5 per cent. of total alkalis, Bessey concluded from calorimetric results and free-lime determinations that the hydrous silicates formed in the pastes had a composition of about $3CaO : 2SiO_2 : xH_2O$. This value of the $CaO : SiO_2$ ratio is in fair agreement with that computed in this study for hydrated cements containing about 1 per cent. of Na_2O.

Concretes made from high-alkali cements and aggregates containing opal or certain other active siliceous materials have been shown by numerous investigations to be unsound. A gelatinous product formed in such concrete is generally associated with this unsound state. Analyses of some of these gels show them to consist largely of silica, alkalis and water (ignition loss), together with smaller quantities of CaO, R_2O_3, MgO, and SO_3.

Because large amounts of $Ca(OH)_2$ are present in concrete, it might seem that the compositions should approximate those of the gels which coexist with $Ca(OH)_2$, as determined in this study. The reported compositions of the gels in concrete are, however, notably and consistently lower in CaO and either higher or lower in Na_2O than those along the boundary.

A theory advanced recently by Hansen to account for expansion of concretes containing " reactive " aggregates and alkalis also appears to explain why such low-lime alkali silicates may be present in concrete. This theory postulates that a membrane, permeable to sodium and hydroxyl ions and water but impermeable to silicate ions, is formed around the " reactive " aggregate particles. As a result of the transfer of the alkali hydroxide solution, an osmotic pressure great enough to cause expansion is produced. Also there occurs a reaction between the alkali hydroxide and the siliceous aggregate forming alkali silicates.

The author's summary of the paper is as follows. The only solids found were $Ca(OH)_2$ and a four-component gelatinous product of variable composition. In contact with crystalline $Ca(OH)_2$ and solutions of increasing Na_2O contents, this gel showed a composition varying between $0·003\ Na_2O : 2·0\ CaO : 1·0SiO_2 : xH_2O$ (at 0·2 gr. of Na_2O per litre) and $0·25Na_2O : 1·0CaO : 1·0SiO_2 : xH_2O$ (at 20 to 101 gr. of Na_2O per litre). By increasing the concentrations of SiO_2 in

solution, at fixed Na_2O levels (6, 13, 50, and 96 gr. per litre), the $Na2O_2 : SiO_2$ molar ratio of the gel was shown to increase to a value of about 0·2 and remain approximately constant at this value. The $CaO : SiO_2$ molar ratio, however, decreased at all NaO levels. The compositions of gels from concrete containing "reactive" aggregates are compared with those of the synthetic gels. It is shown that the low-lime gels formed in concrete approximate in composition those in the study in contact with solutions the $SiO_2 : Na_2O$ ratio of which approaches a value of 3.

Permeability of Concrete to Fuel Oil.

THE increased wartime use of concrete tanks for storing Diesel oils, light fuel oils, and petrol induced the United States Bureau Standards to undertake a limited investigation of methods for rendering concrete adequately impermeable to these products. Measurements were made by Mr. F. B. Hornibrook of the daily inflow of paraffin under a 12ft. pressure head into one face of specially treated concrete discs.

The penetration of paraffin into 14-day old untreated concrete was relatively low, but after the concrete dried for six weeks the penetration was high. The use of integral admixtures and of lacquered instead of oiled shuttering reduced the penetration, but not enough to be economically adequate. Sodium silicate or magnesium fluosilicate applications were not significantly effective; but a plain, well-trowelled plaster coat of cement-sand mortar reduced the rate of penetration of the paraffin to a low value. Whether the development of shrinkage cracks on a large surface treated in this manner would nullify these results remains a question. Powdered iron-type admixtures in the mortar coat reduced oil penetration, and one magnesium oxy-chloride type of coating looked promising if used where exposure to drying or to water is not excessive. This type of coating has the advantages of low cost and easy application. Spar varnish was effective in reducing penetration, but would require long-time tests to indicate its permanence to such exposures. Polyvinyl chloride type paints and poly-sulphide emulsified latex linings were effective and are reasonably stable to water, oils and petrol. However, these materials are expensive and the cost of applying them is high, so that their use is warranted only under special conditions.

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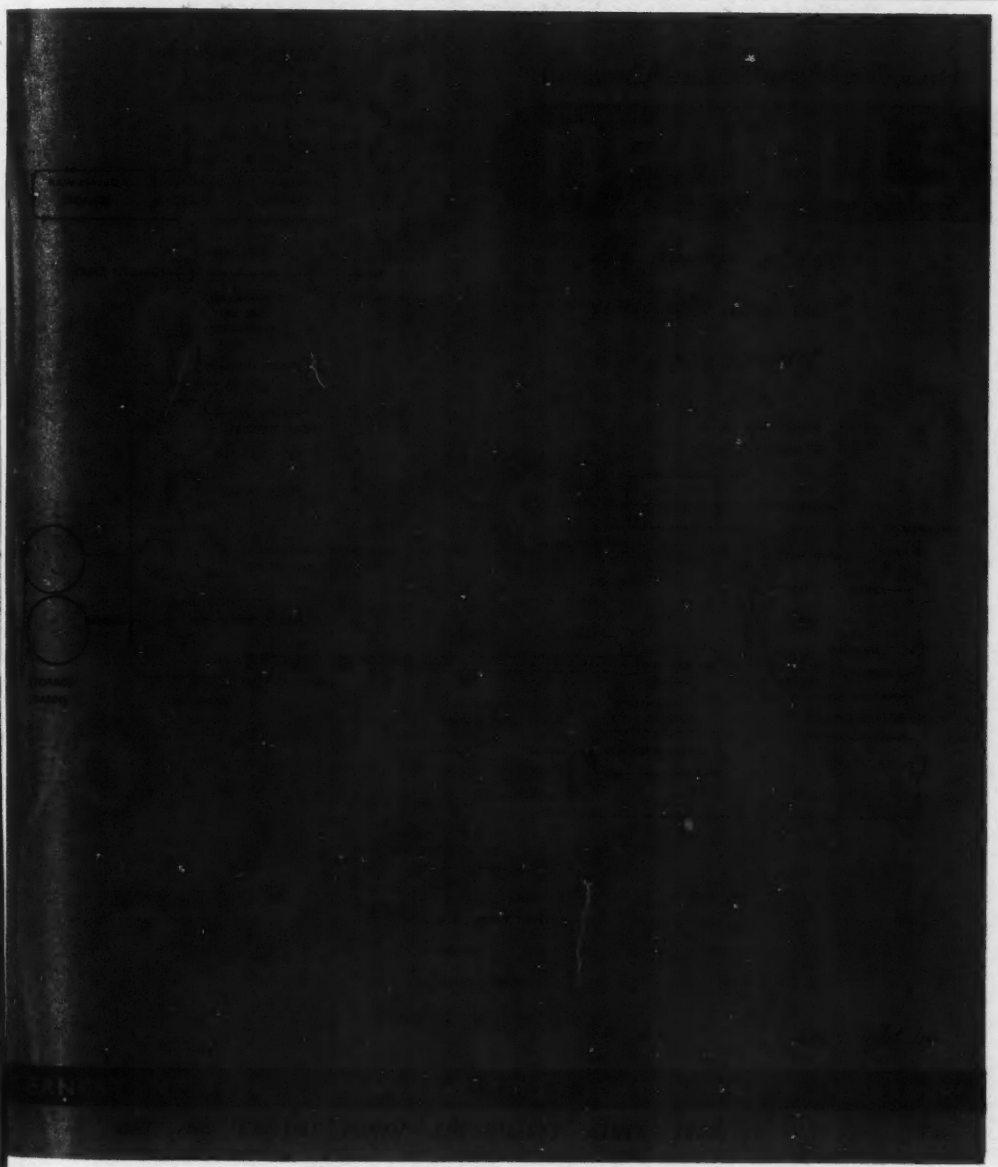

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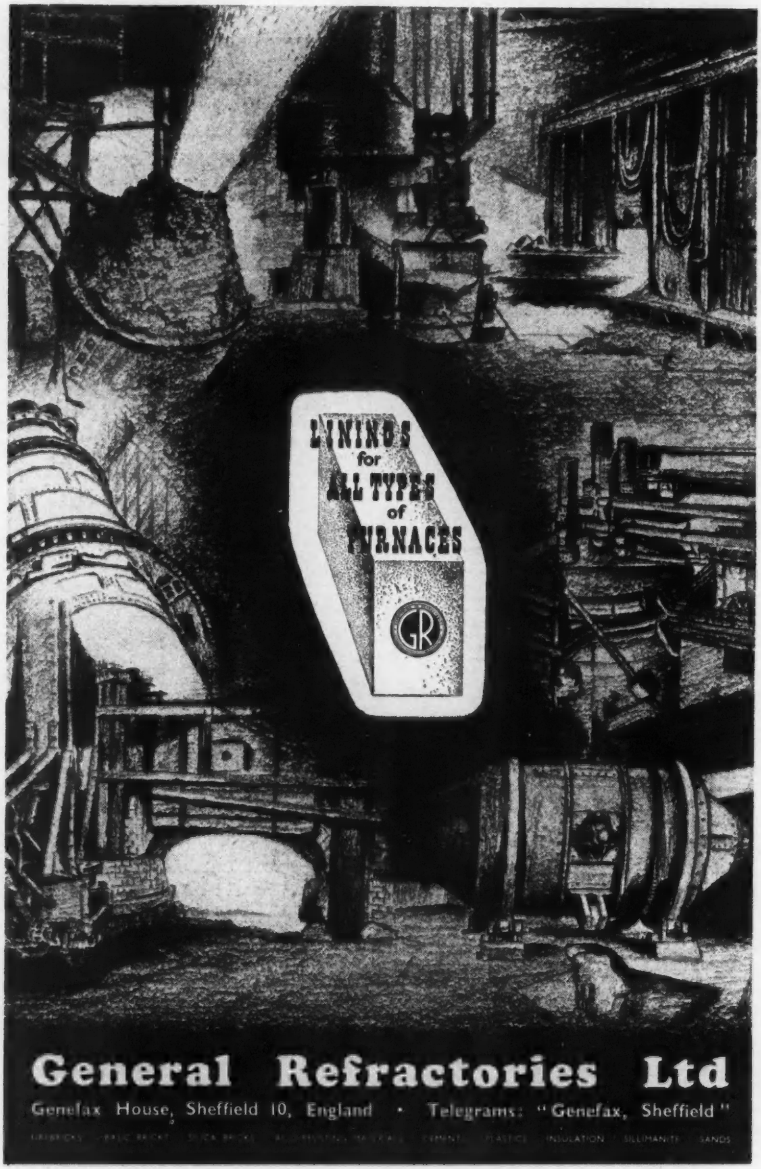
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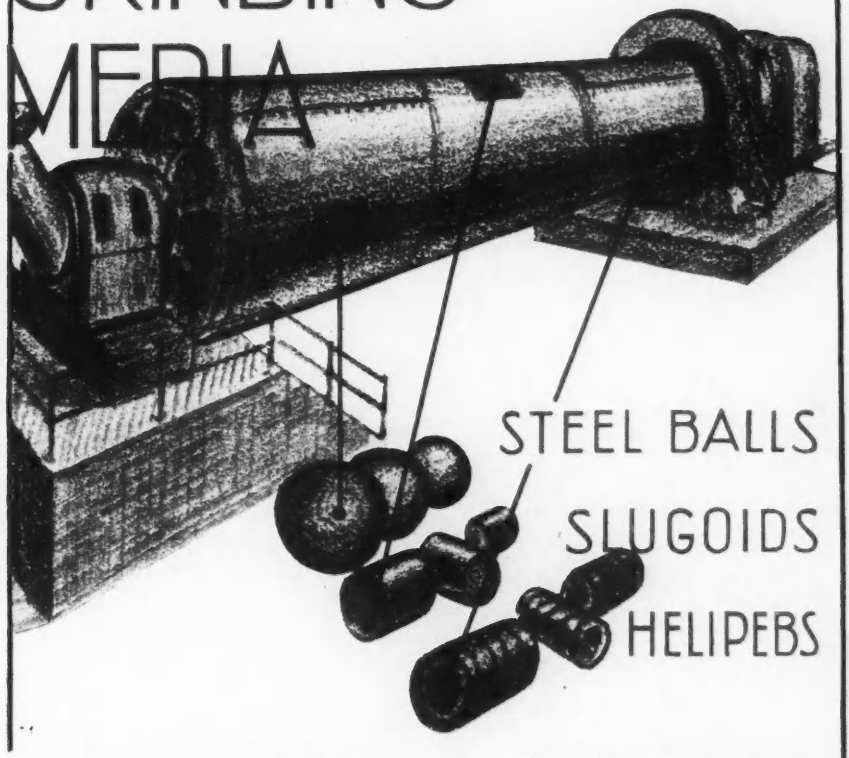

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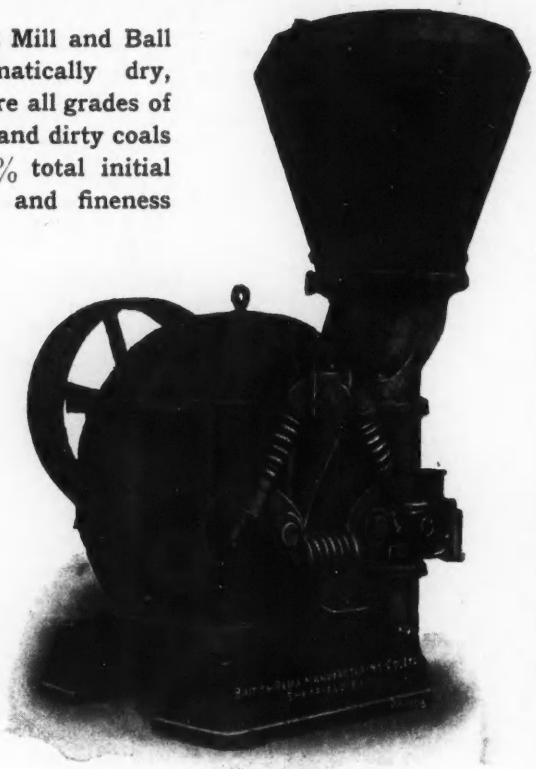

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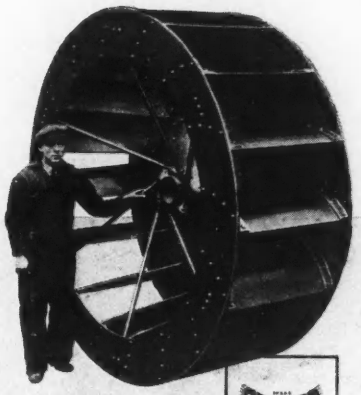

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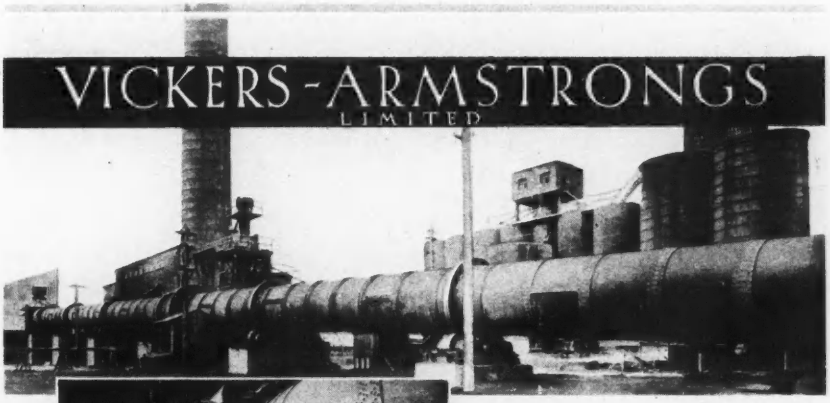

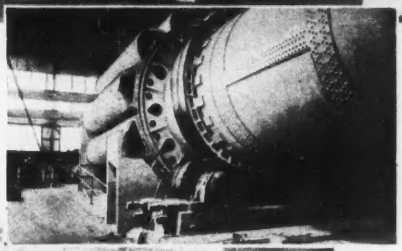

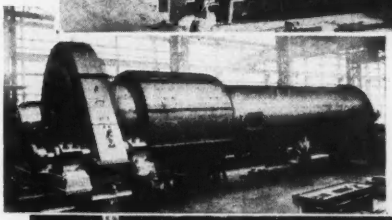

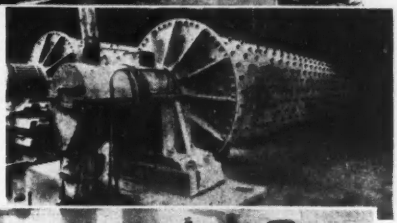

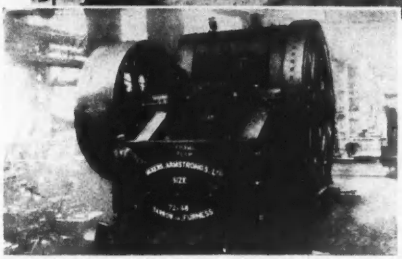

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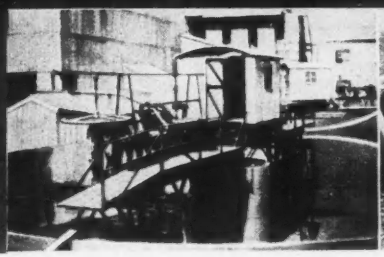

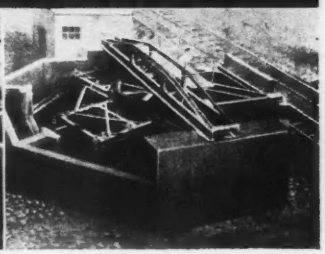

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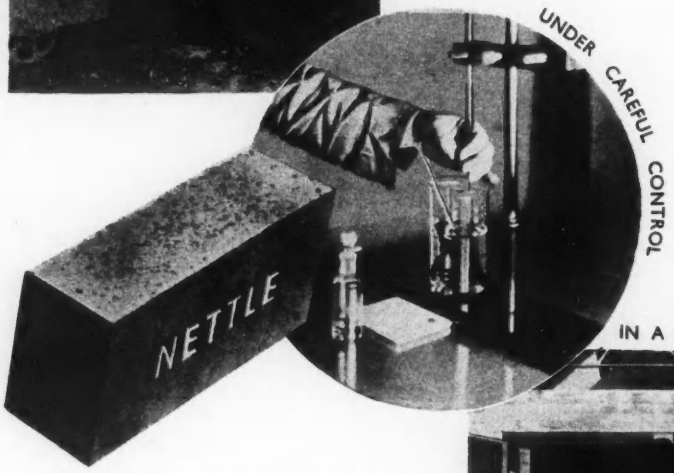

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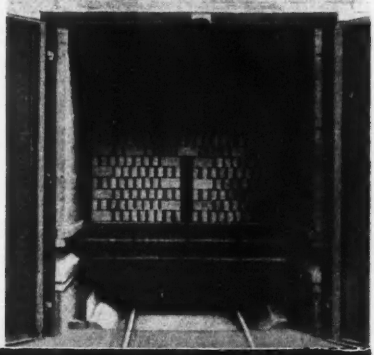

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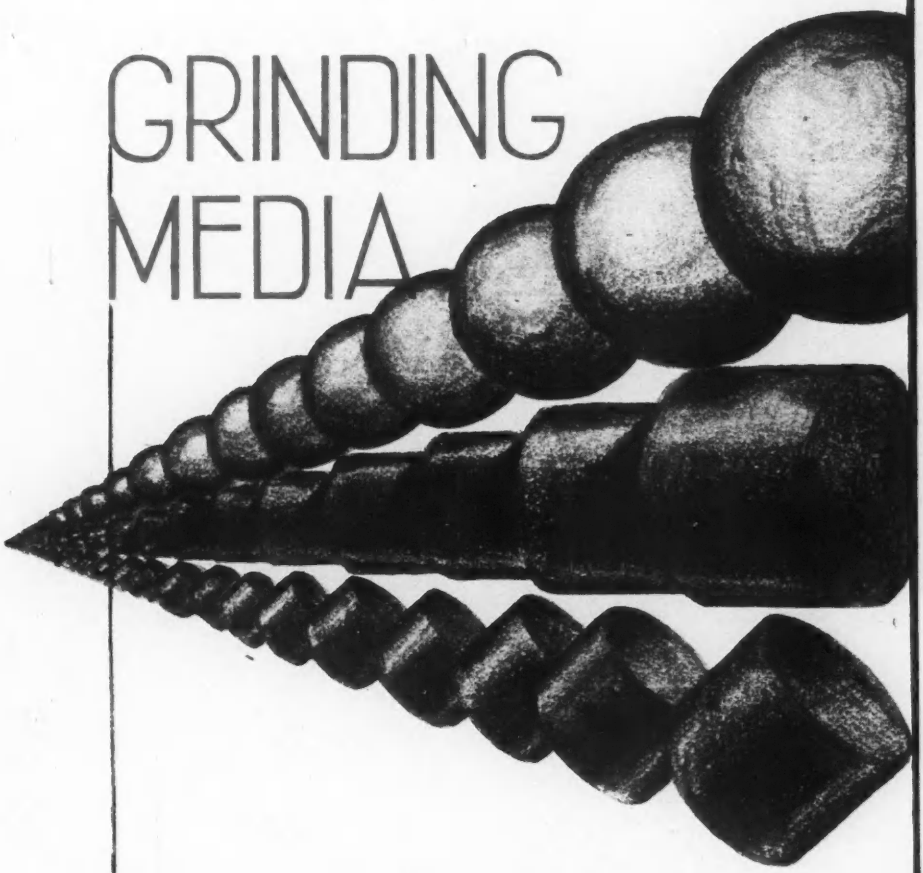

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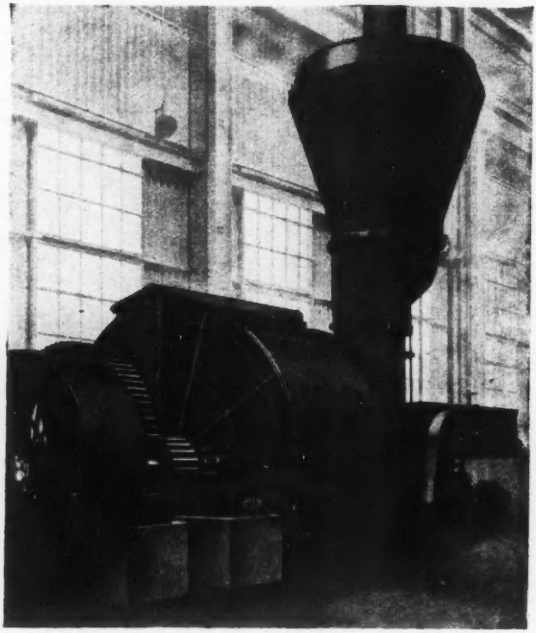

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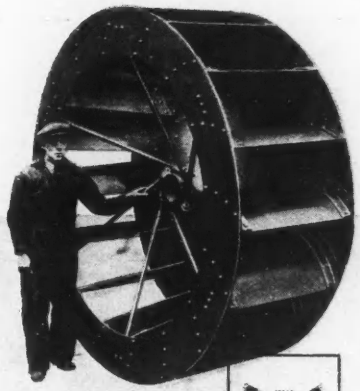

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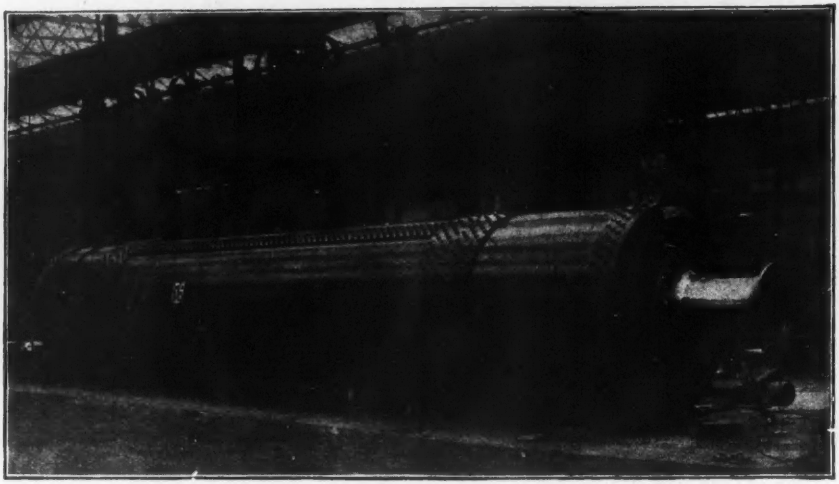

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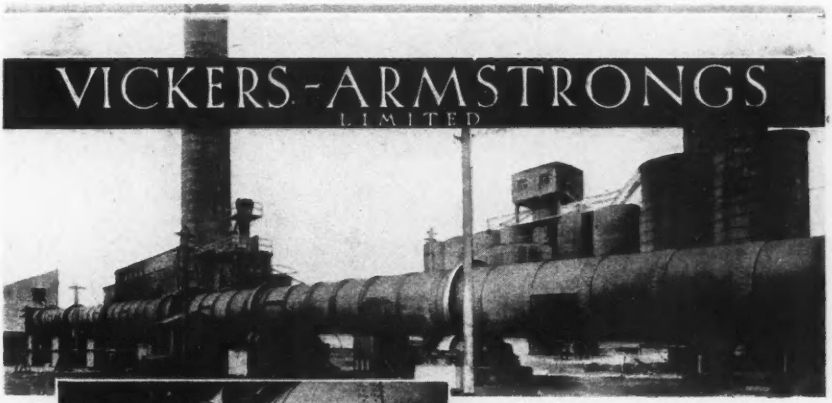

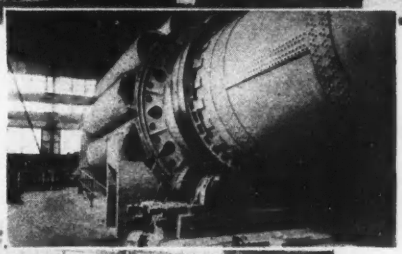

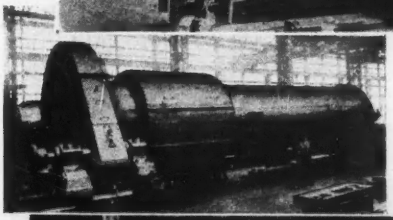

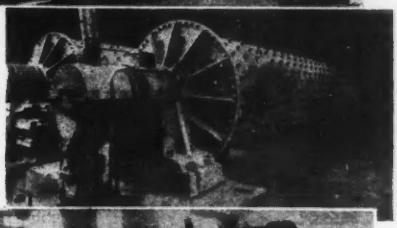

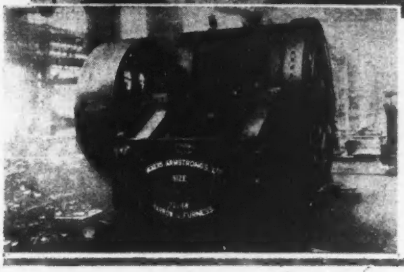

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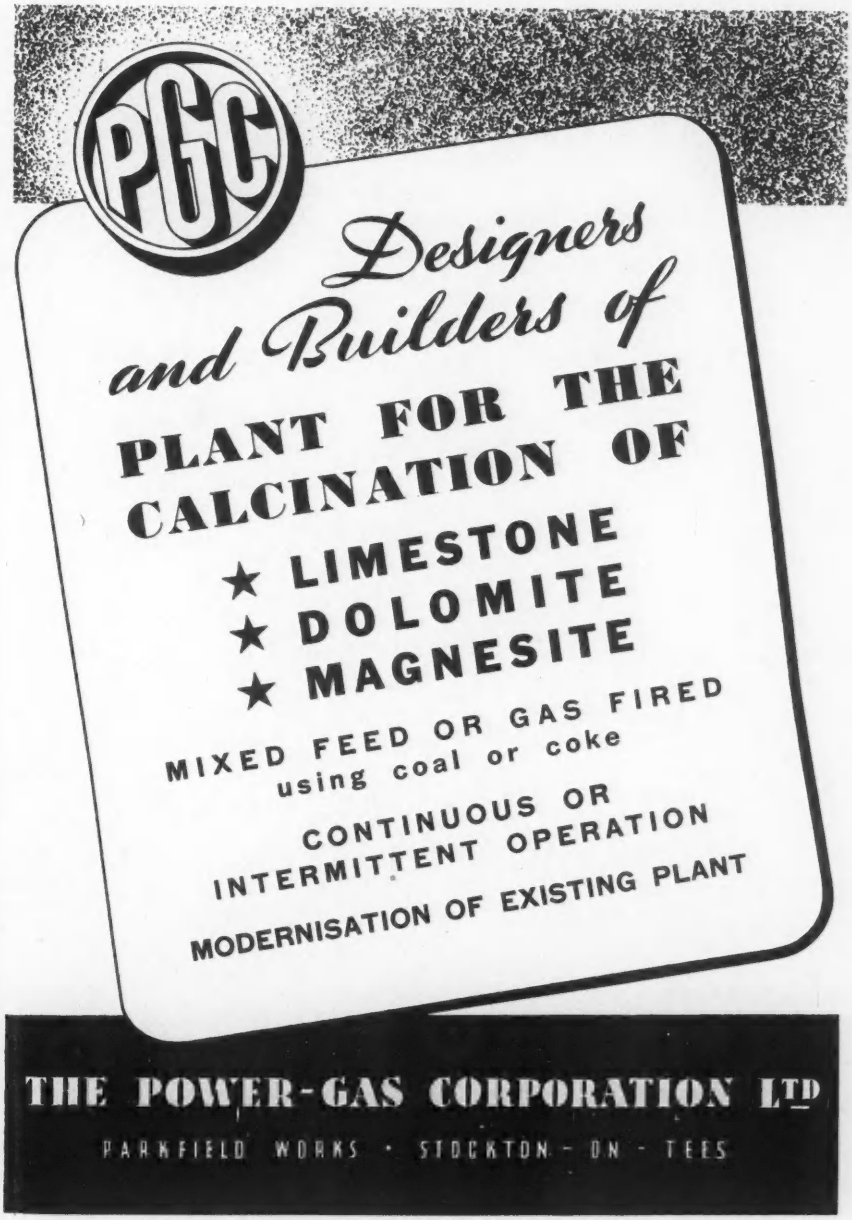
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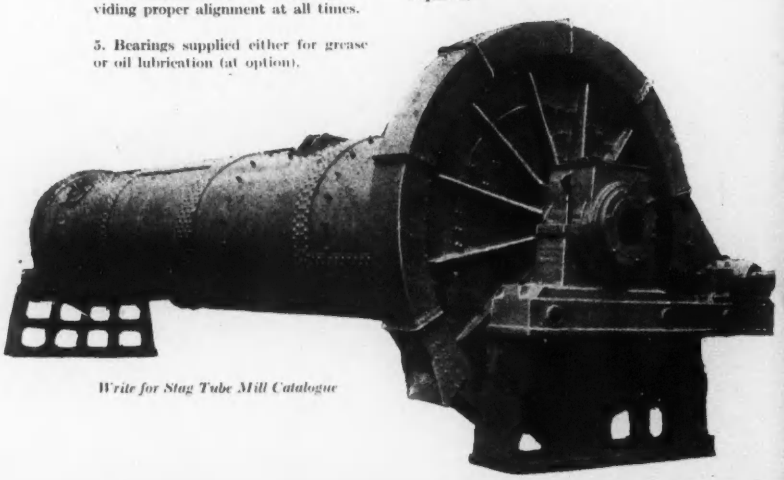

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CEMENT AND LIME MANUFACTURE

Vol. XVII. No. 3 MAY 1944 PRICE 1/- ALTERNATE MONTHS

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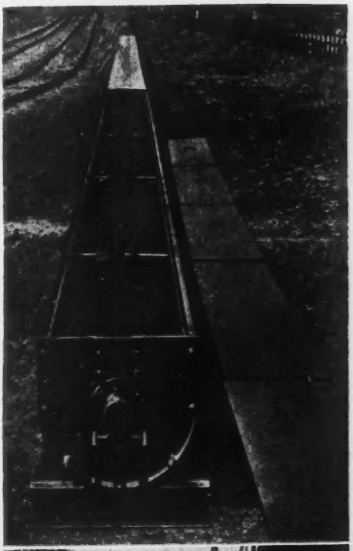

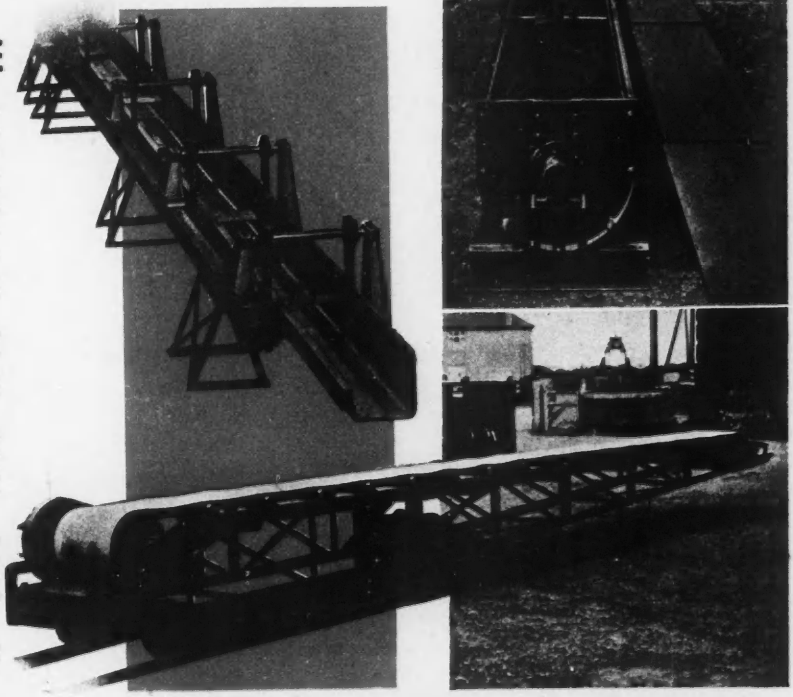

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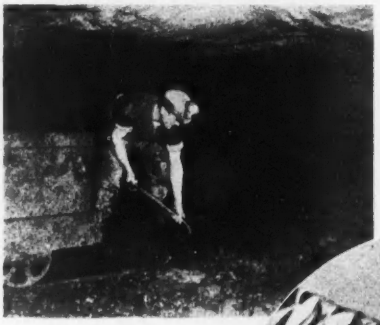

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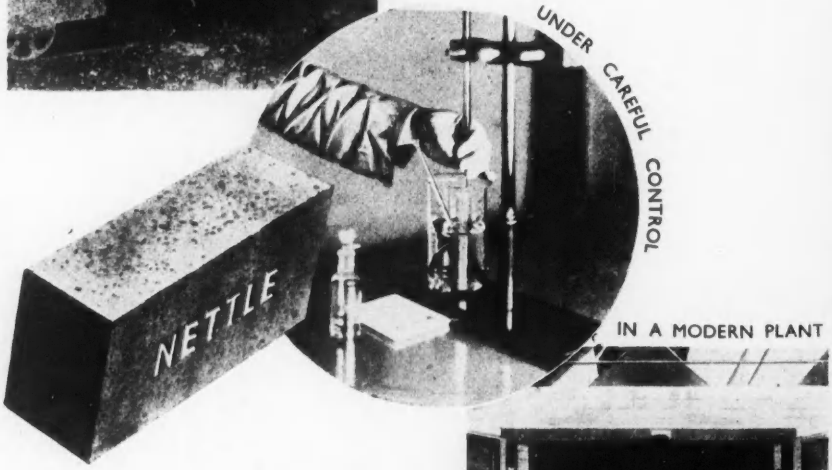

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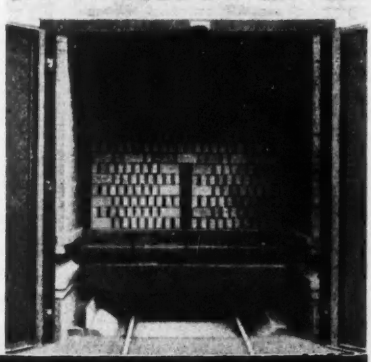

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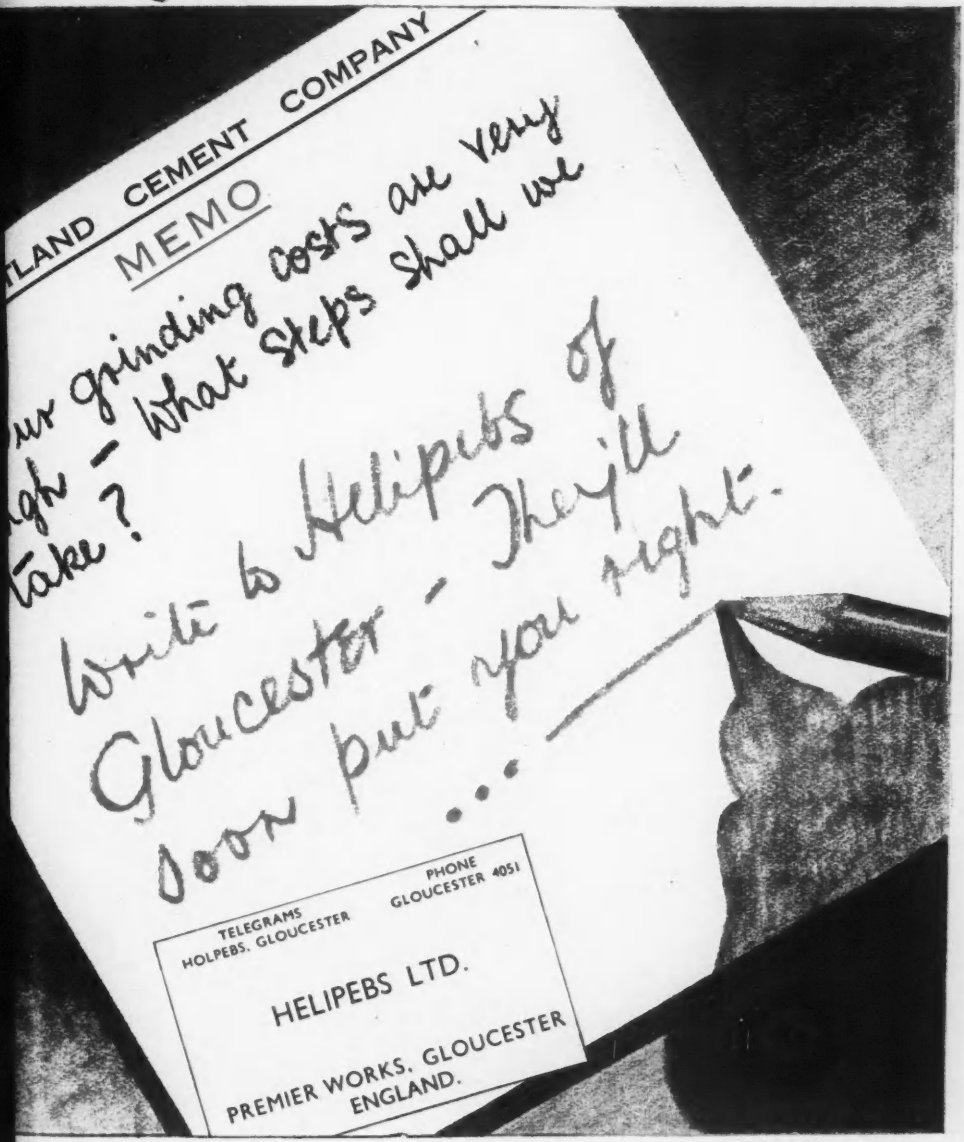
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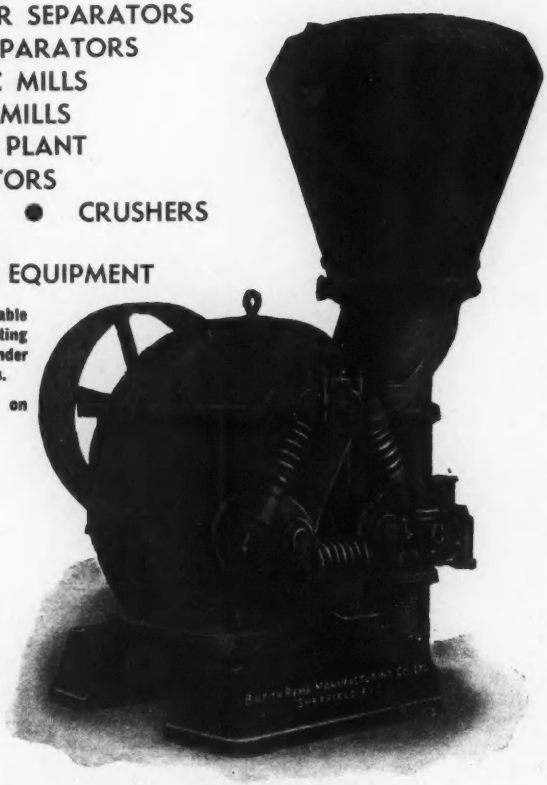

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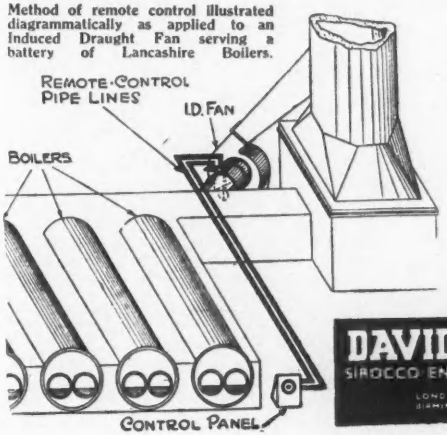

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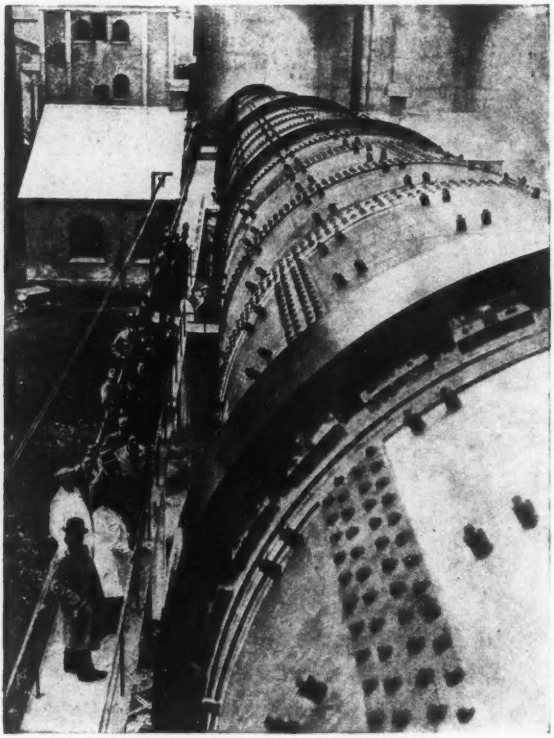

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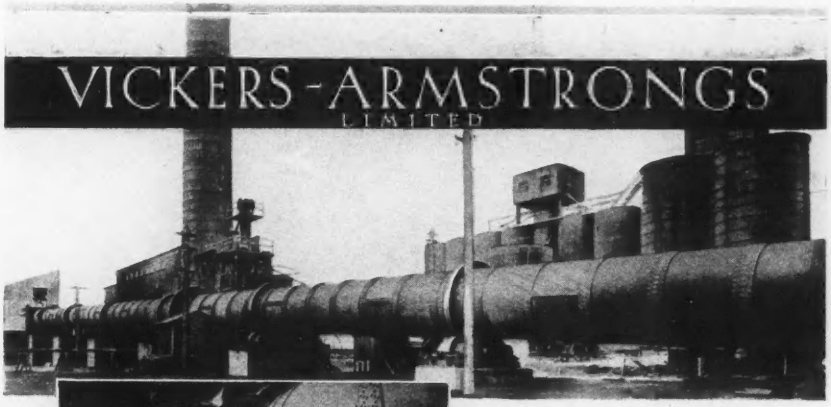

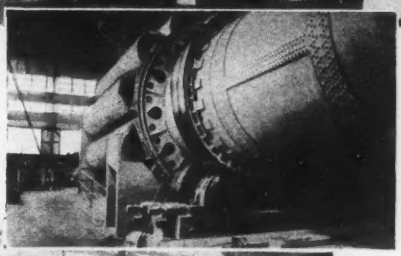

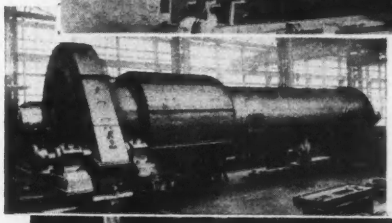

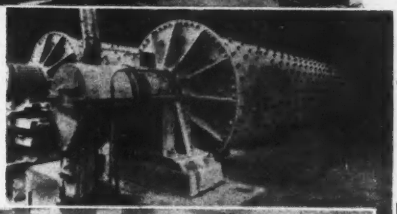

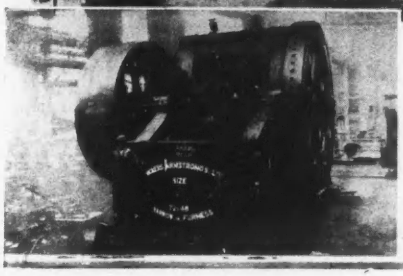

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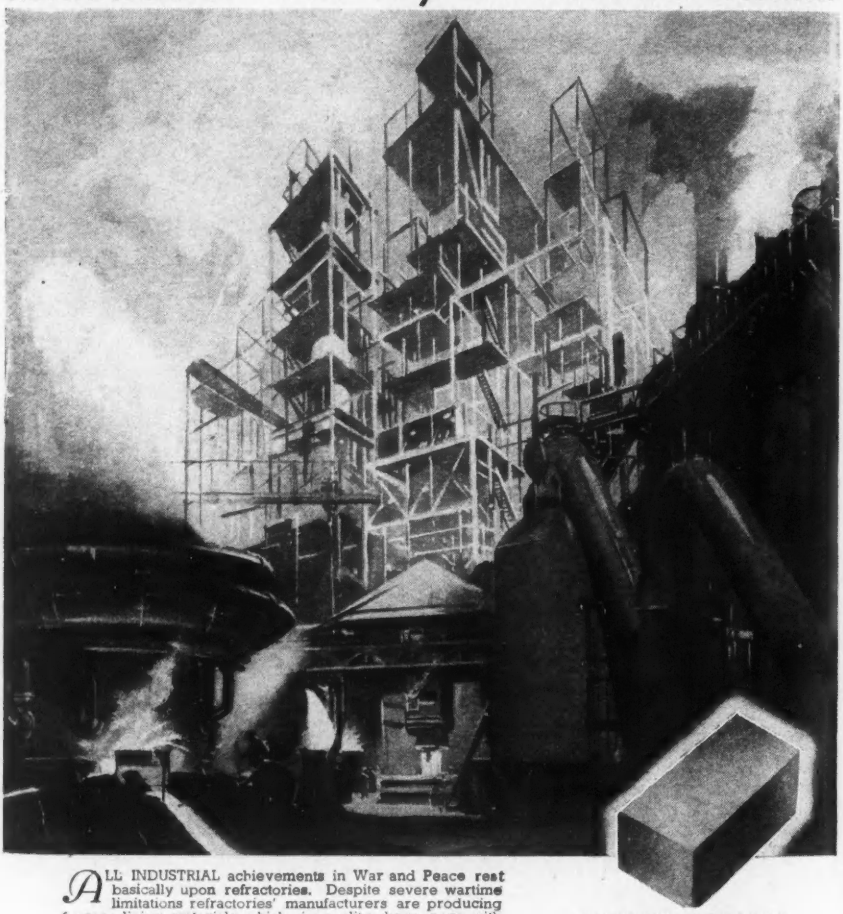

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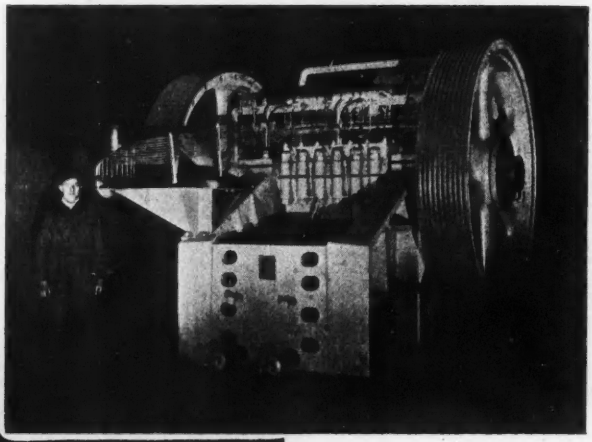

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CEMENT AND LIME MANUFACTURE

National Bureau of Standards
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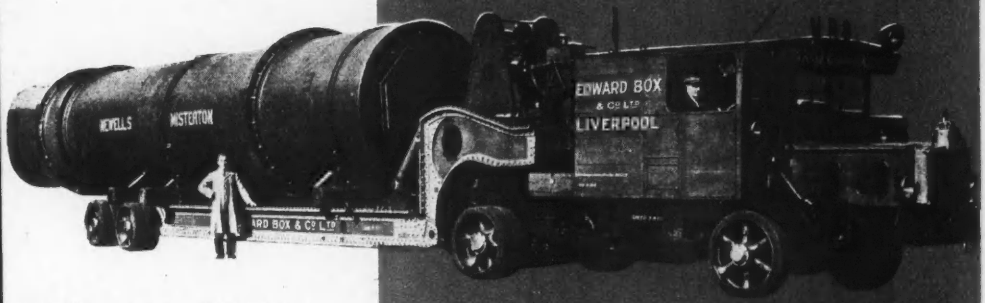
Vol. XVII. No. 4 JULY 1944 Price 1/- Alternate Months

NEWELLS

LIMESTONE WASHERS



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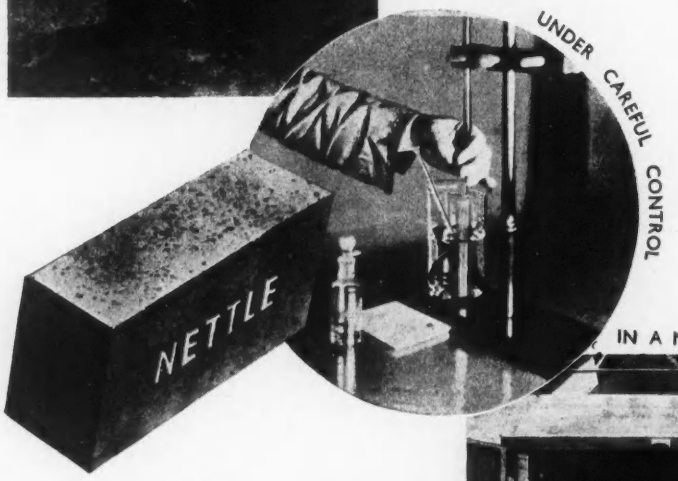

We strongly advise the use of standard sizes (i.e., Squares and Cupola shapes 9"×4½"×3", 9"×6"×3", 13½"×6"×3", etc.) rather than Special Blocks. The former can be machine pressed, with the following advantages:

- **Denser texture — therefore better resistance to corrosion.**
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- **Lower Cost.**
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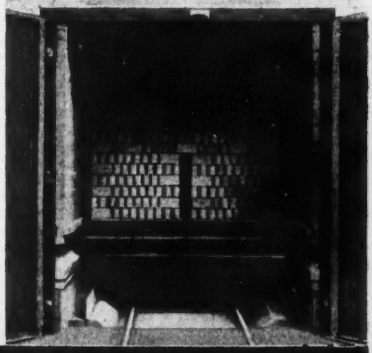

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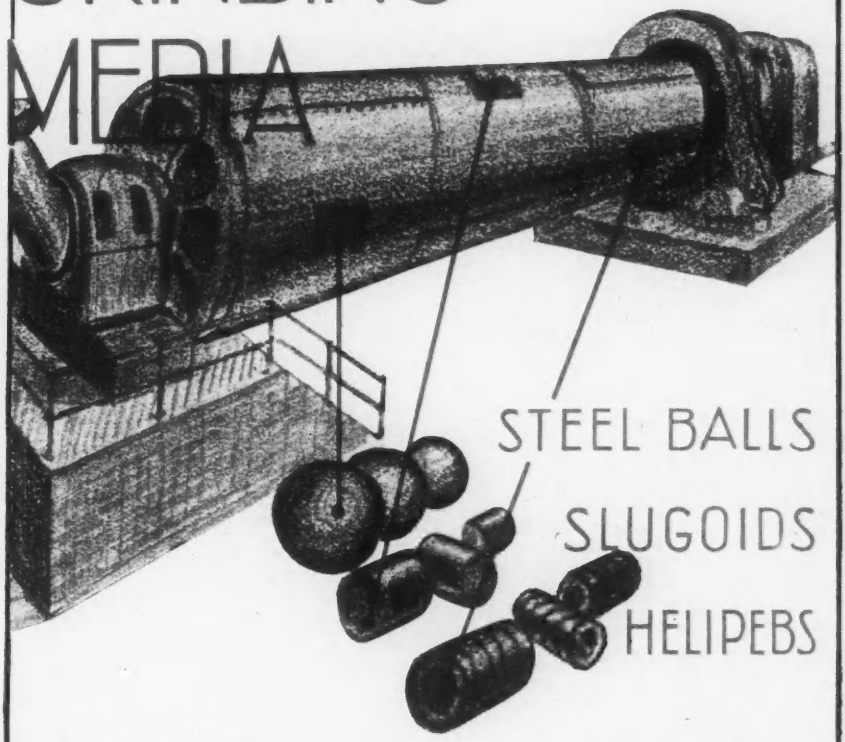

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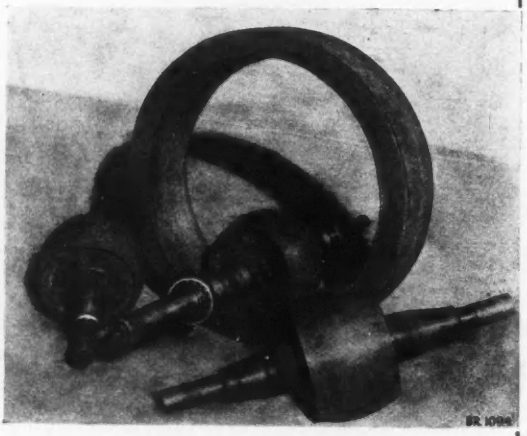

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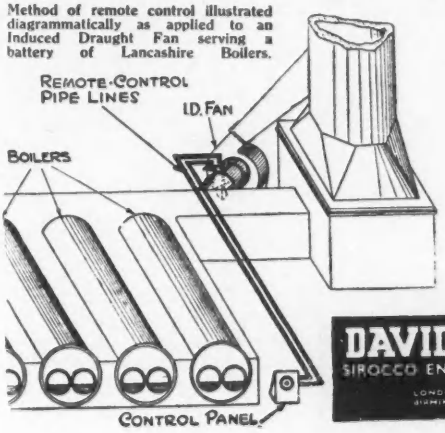
Method of remote control illustrated diagrammatically as applied to an Induced Draught Fan serving a battery of Lancashire Boilers.



"SIROCCO" Mechanical Draft Fans equipped with Inlet Control can be regulated from the firing platform with less effort than is required to lift a shovel.

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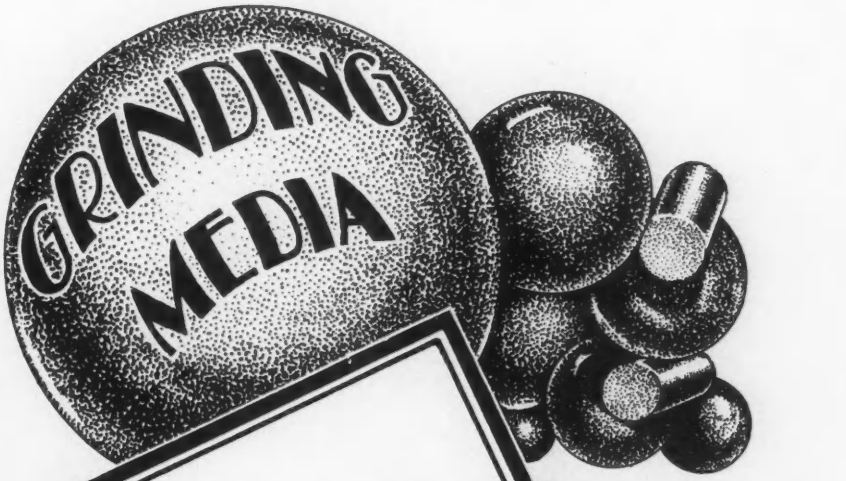

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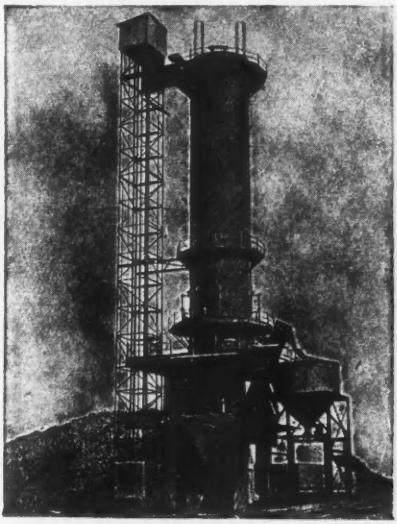

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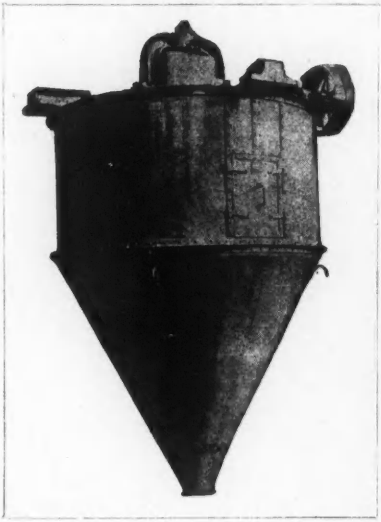

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Vol. XVII No. 5 SEPTEMBER 1944 PRICE 1/- ALTERNATE MONTHS

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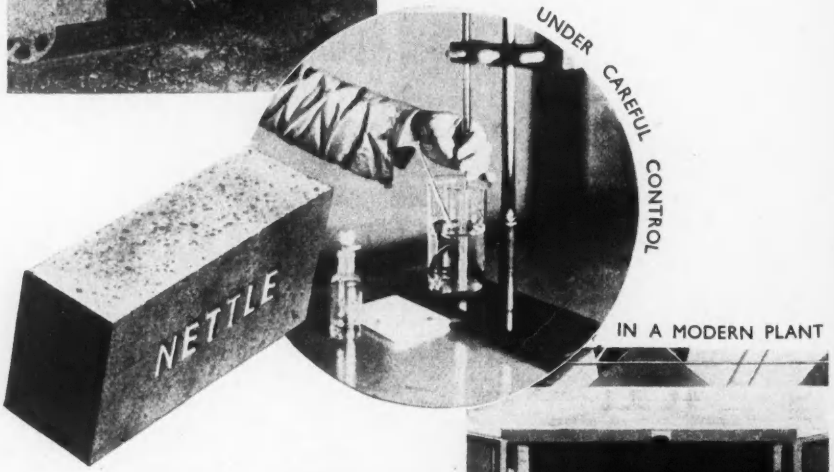

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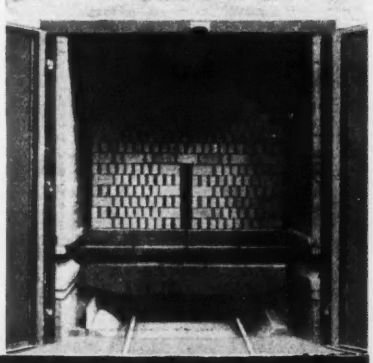

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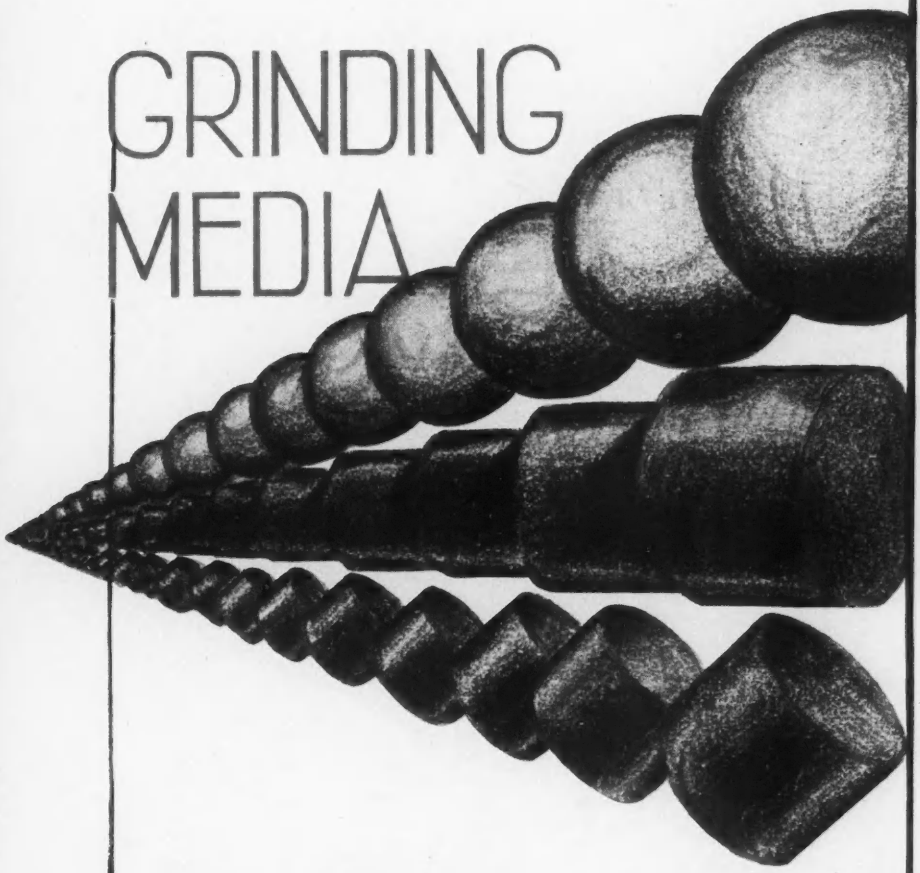

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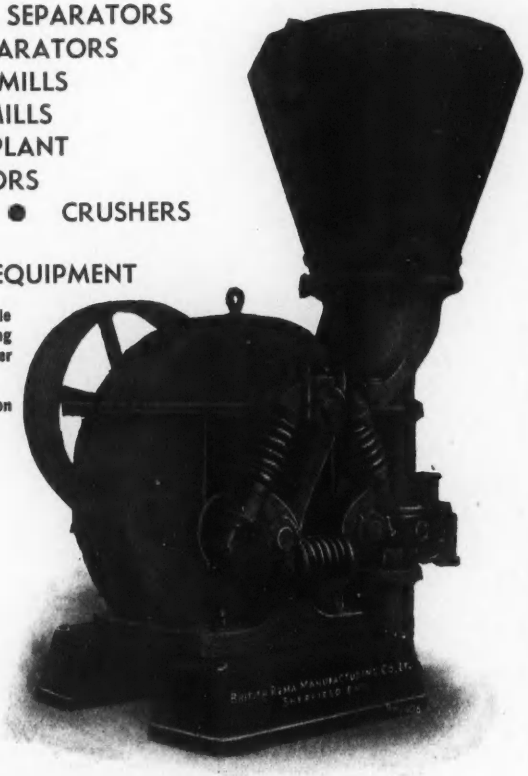

Typical layout of British "Rema" Ring Roll Mill Firing Plant operating on the unit system.

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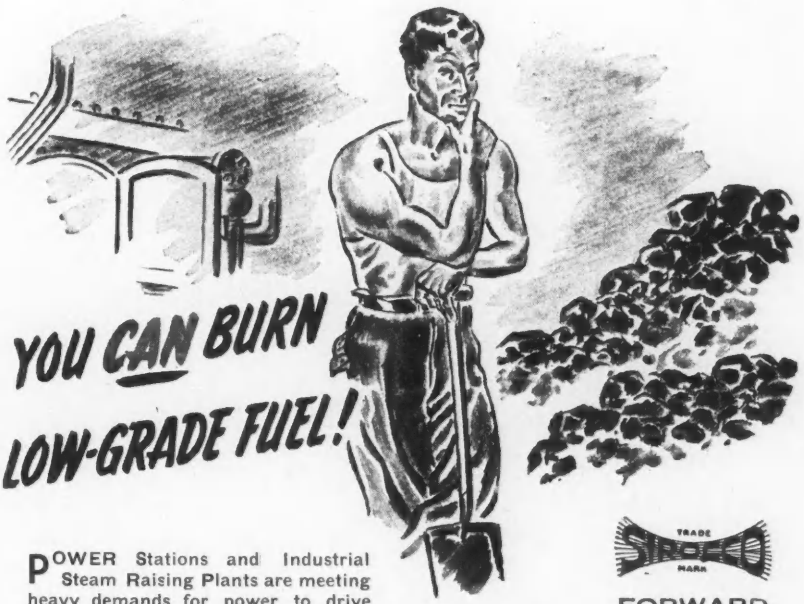

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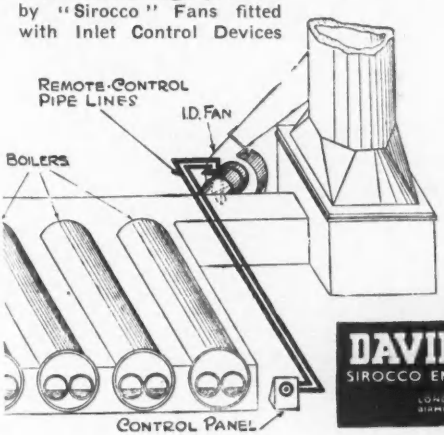

The illustration shows a method of remote control illustrated diagrammatically as applied to an Induced Draught Fan serving a battery of Lancashire Boilers

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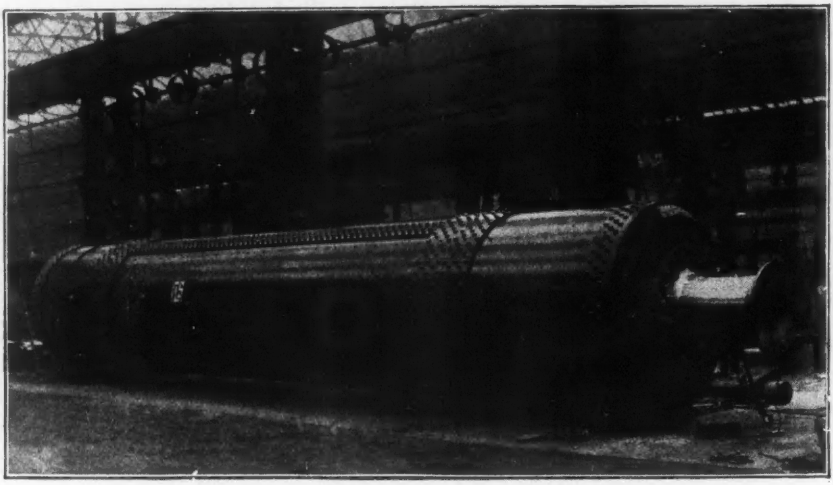

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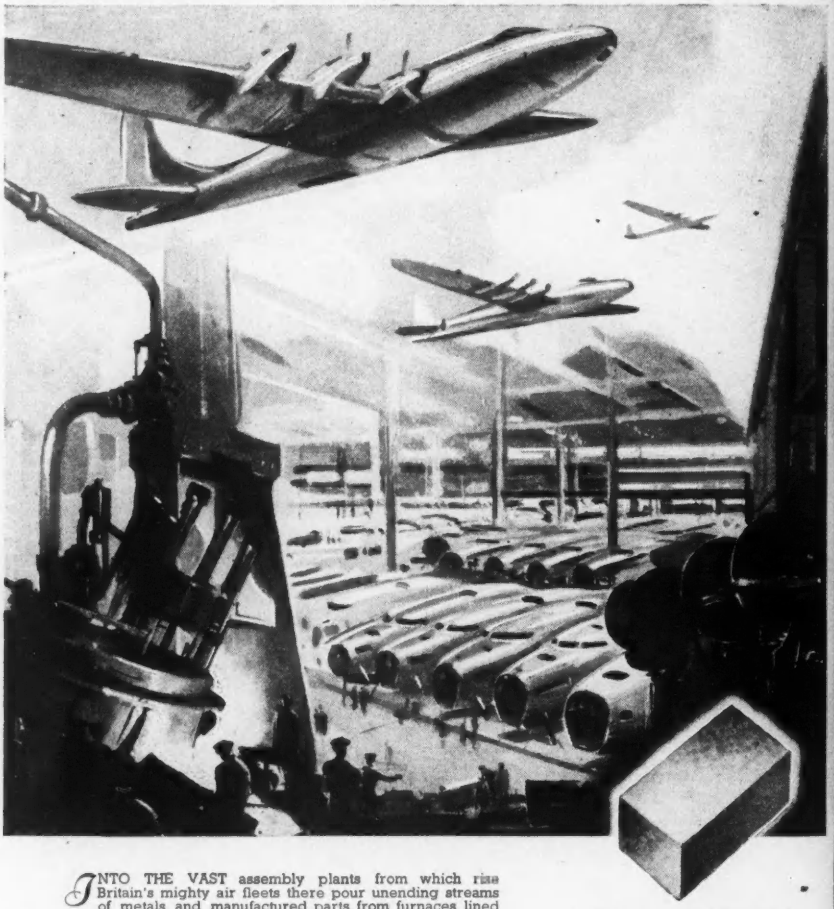

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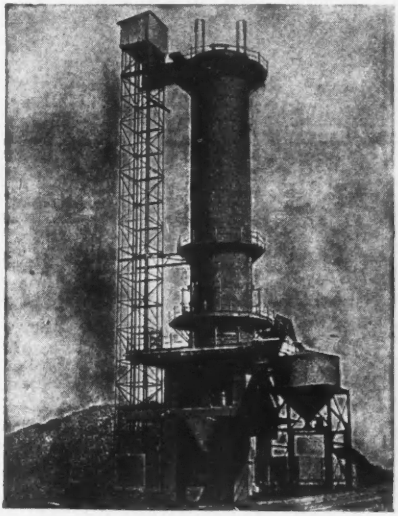

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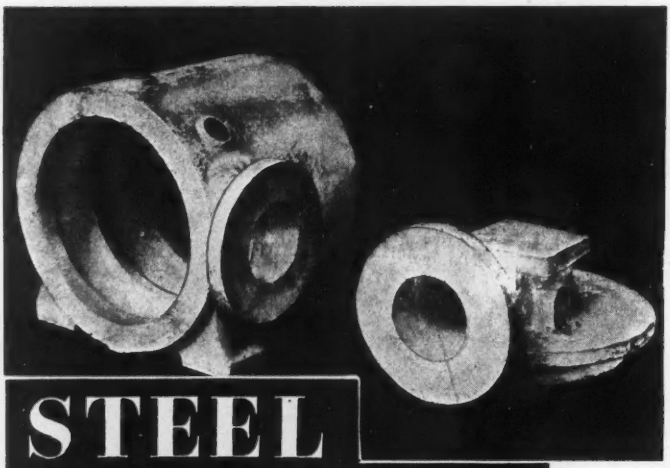

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Vol. XVII. No. 6 NOVEMBER 1944 PRICE 1/- ALTERNATE MONTHS

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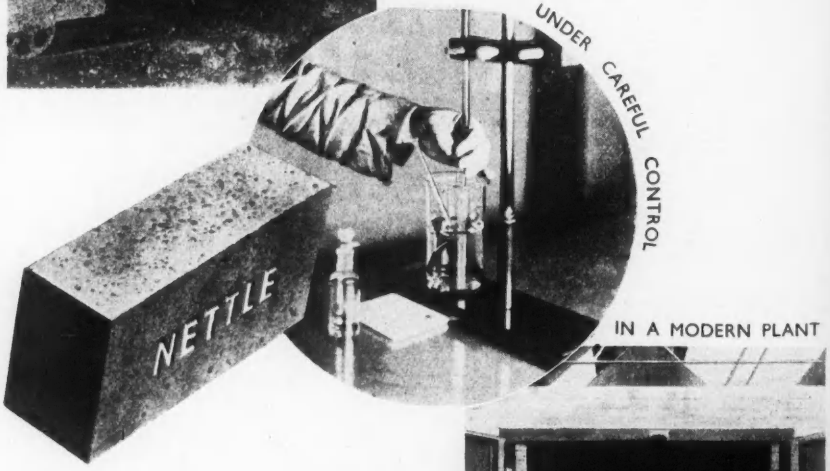

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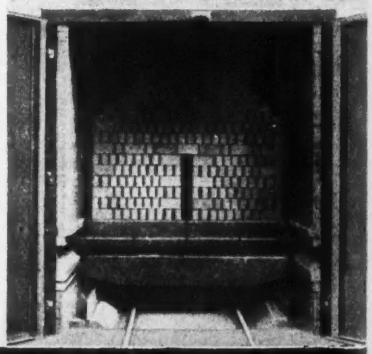

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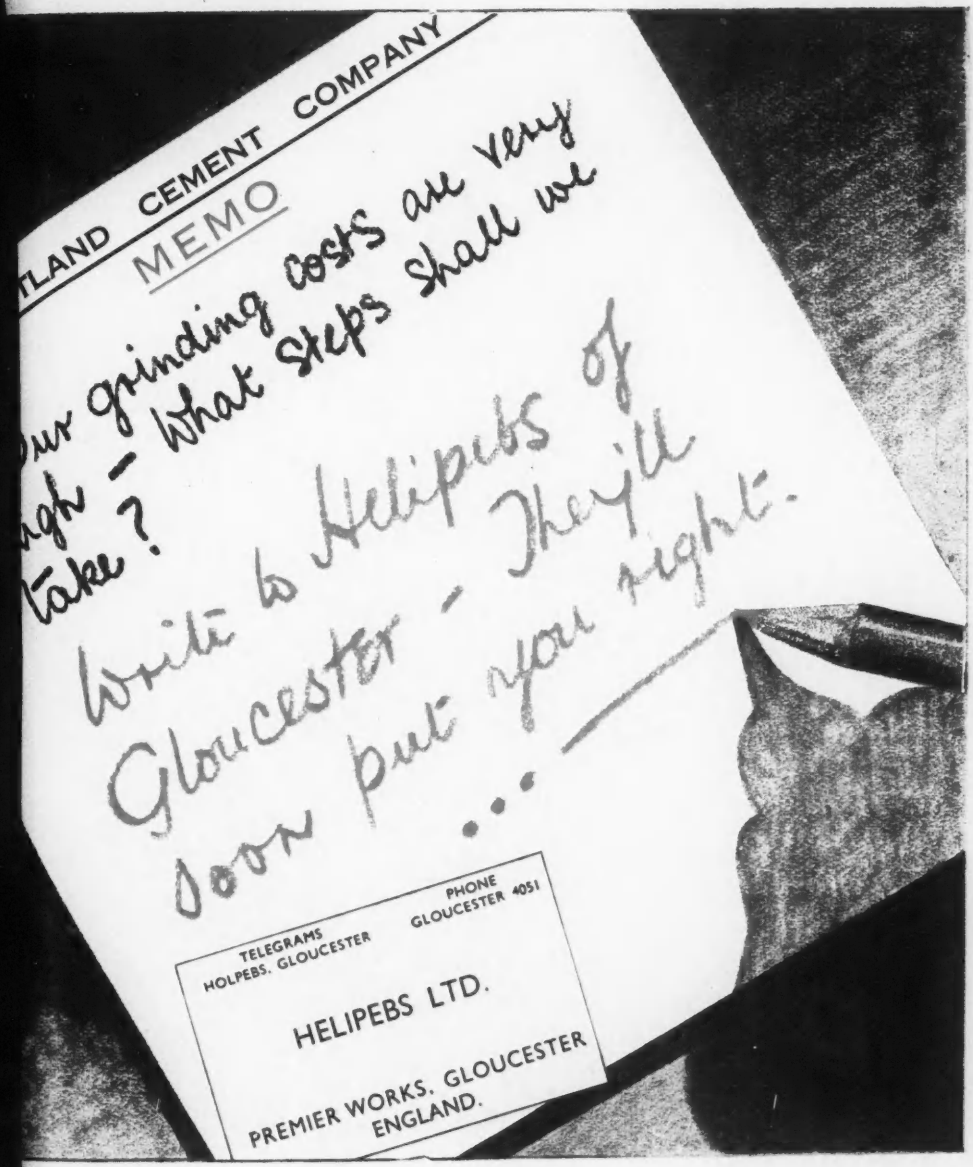
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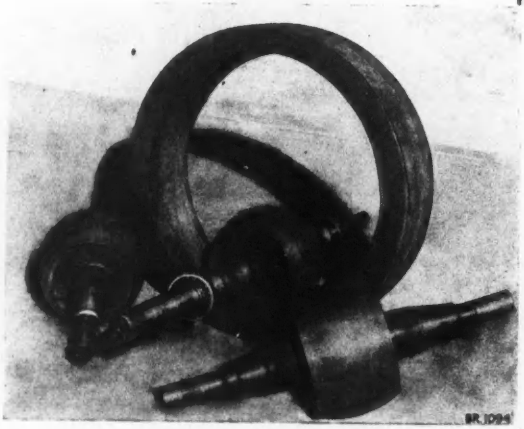

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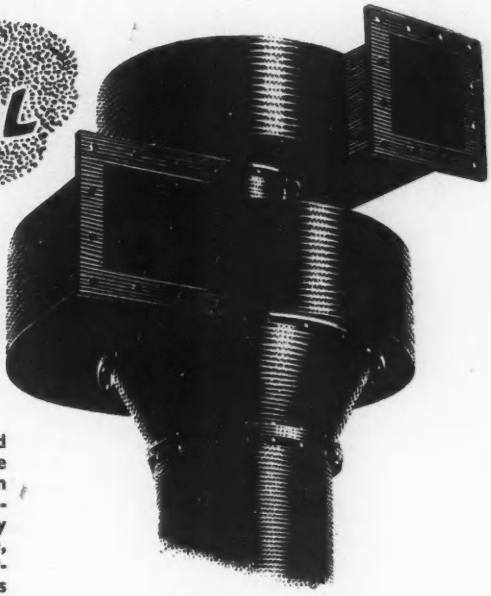

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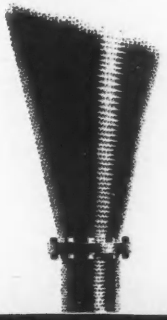

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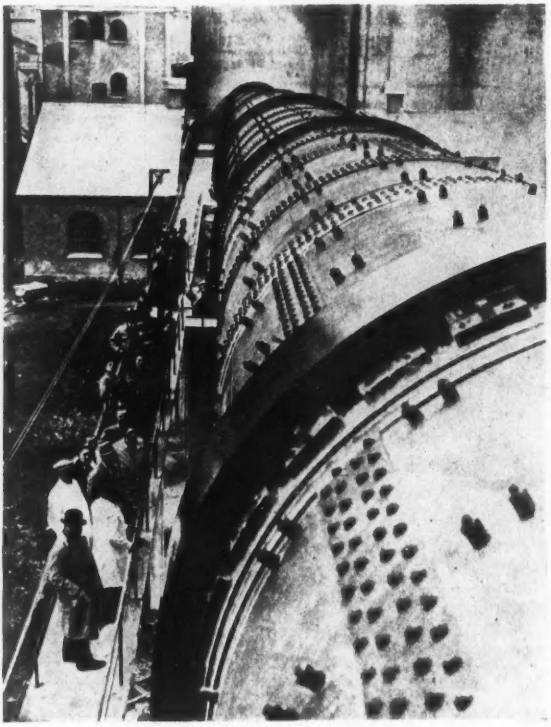

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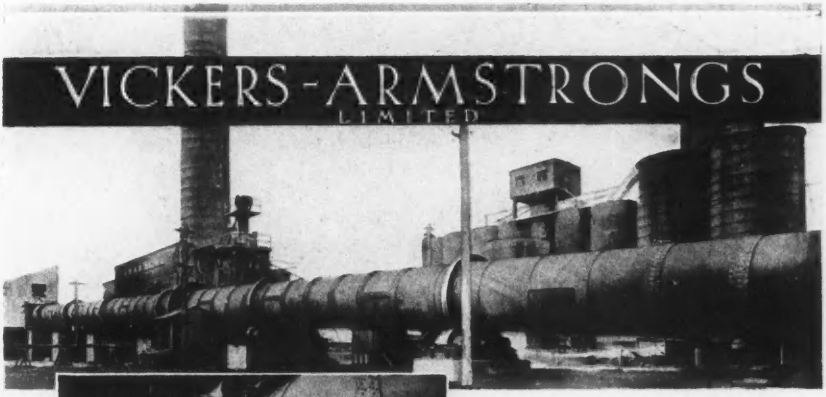

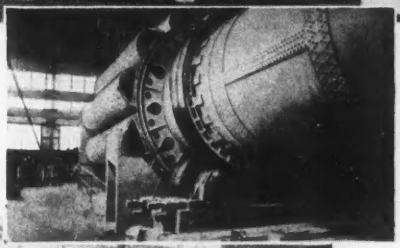

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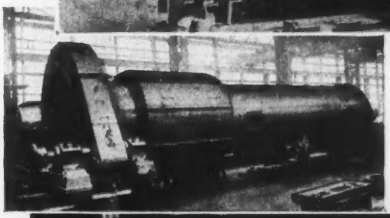

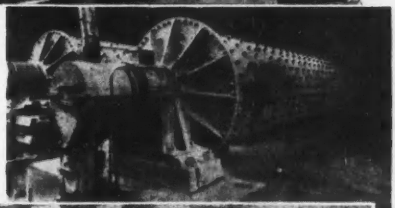

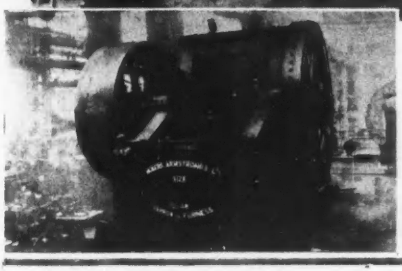

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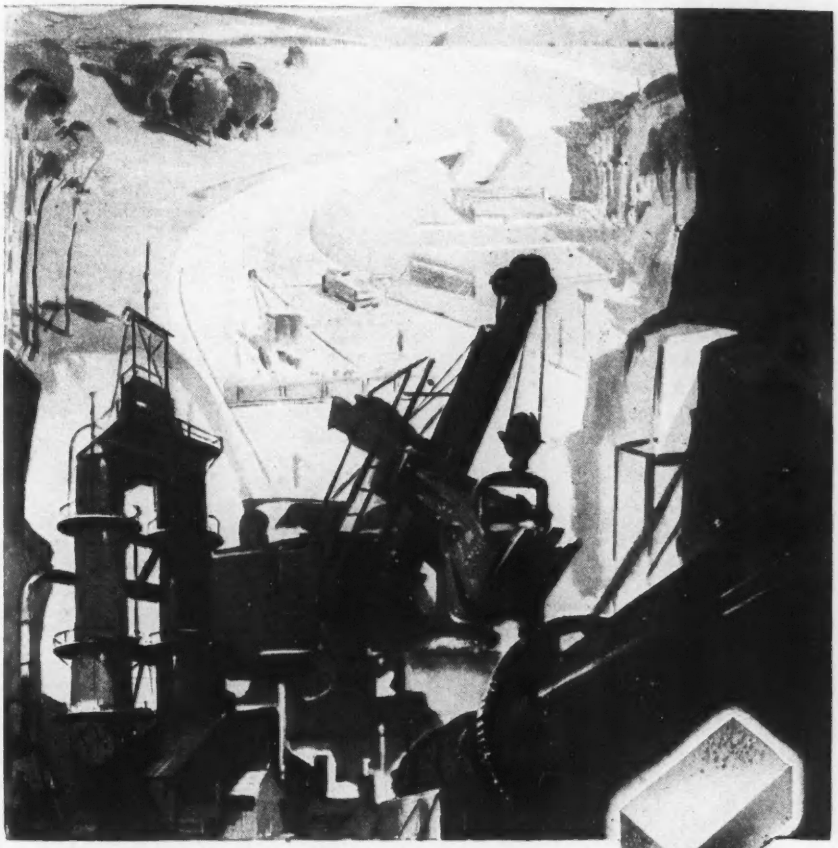

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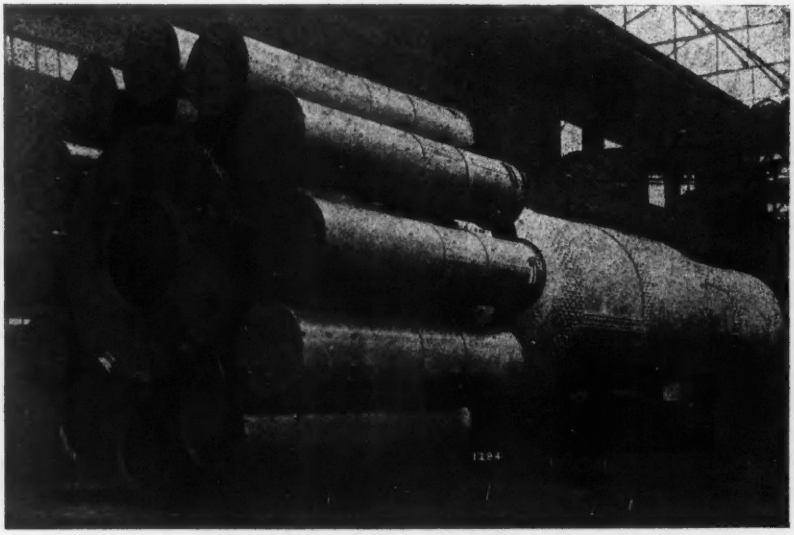

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